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BASIC TRAINING GUIDE

READING OF AIRCRAFT DRAWINGS



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The DIFFERENT Views *of a Drawing*



Section 1.



Reading aircraft drawings will be an important part of your work at the Air Depot. You may not be asked to *make* such drawings, but you must be able to *use* them. For this purpose you do not need a long and complicated course on the technicalities of mechanical drawings. Instead, you can learn swiftly about the different kinds of drawings used most frequently in your work.

You might think that the best way to find out about an airplane would be from a good photograph. American engineers, however, could not figure out the detailed construction of the Japanese Zero planes from the first pictures available. After a Zero was shot down, they secured more information by looking at it from all sides. They understood it completely after they had looked at it from the inside, had taken it apart to see how it was made, and finally had made drawings to gather together the details of their observation. In normal manufacture of planes, such drawings are made *first* and the parts are built from them.

By using these drawings of plane parts for guides, you will be able to manufacture

or repair parts so that damaged or worn planes may fly again. You can get the general appearance of a part from a photograph, but you will need drawings to show you how it looks from the top, from the side, from the front, in cross section, and from all angles. These drawings are carefully labeled so that you know how big the part is, what material it is made of, and how it is made.

Learning to use such a drawing is like learning to read a road map or use a dress pattern. After you find out the meaning of the abbreviations and lines on the pattern or road map, and after you have some practice in using them, you interpret their meaning without difficulty. Likewise when you understand the meaning of the abbreviations, lines, and views, and have had some practice, the use of drawings is not difficult. It is the purpose of this book to tell you what the lines and terms in aircraft drawings mean, and to help you use them successfully.

To get a complete picture of anything you must look at it from more than one point of view.

If you stand directly in front of the house shown in fig. 1, looking squarely at it, you get some idea of what it is like. But you cannot tell very much about anything else except the front of it. You don't know how far back it extends, or what the shape of it is like, except what you can see from the front.

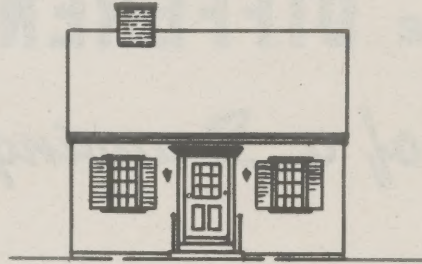


Fig. 1.

If you look at it from the side also, as shown in fig. 2, you get more information about it. You see that it has two stories, and that there are four windows on this side. You notice a rear porch. From the width of the chimney you might assume that the house has a fireplace. You cannot tell whether the porch is in the middle of the back of the house, or near one end; nor can you tell how many windows there are on the back or how long the porch really is. To get this information you must look at it from the rear as well.

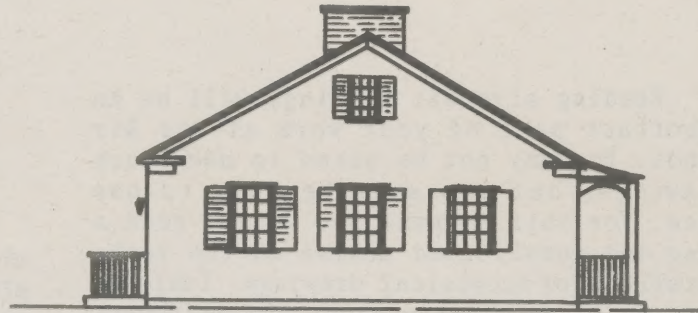


Fig. 2.

Standing now at the rear of the house you can see there are two windows and a door just as there are in the front. You can also see that the back porch is larger than the front steps or stoop, that it is in the center, and that it reaches out and covers both windows. You could not know this by standing only at the front or at the side; you had to go around to the back and look at it also from there. From each position (or view, as it is called on a drawing) you saw something you could not see from the others.

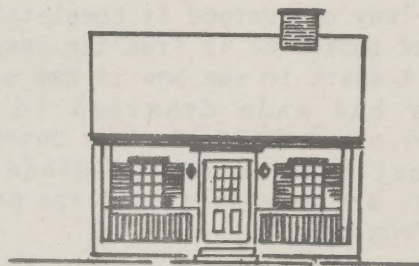


Fig. 2a.

As it was with the house, so it is with the airplane. In order to have a true picture of **fig. 3** we must look at it from more than one side. We find that looking at the plane from three different positions gives us a pretty good idea of the plane. A *top* view, a *front* view, and a *side* view are the ones commonly used.



Fig. 3.

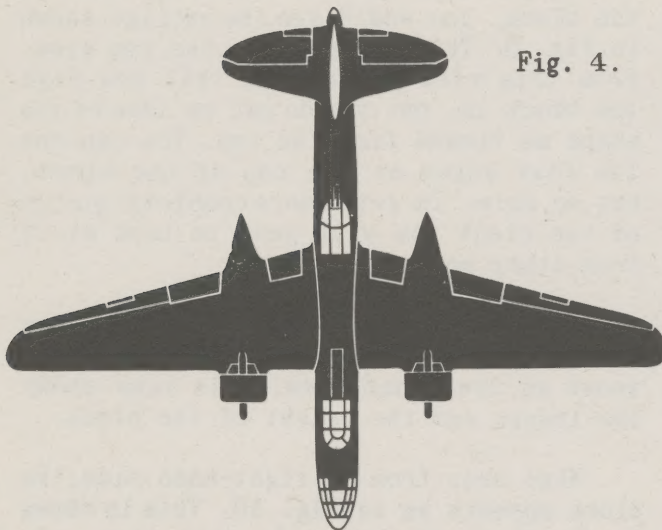


Fig. 4.

Let us imagine ourselves above the airplane shown in **fig. 3**. It now appears as shown in **fig. 4**. We are looking directly down on it, and see the *top* view.

In **fig. 4** we are able to see the shape of the wing, the tail surface, and the general shape of the body or fuselage. We can see also the position of the rudder and can get an idea of the wing span as compared with the length of the plane.



Fig. 5.

Let us change our position and get directly in front of the plane. From this position we see what is called the front view, shown in **fig. 5**. We can see the shape of the fuselage, the position of the tail surfaces, and the height of the rudder and cockpit.

Although a photograph or a picture drawing (which looks much like a photograph) shows a great deal about an object, we

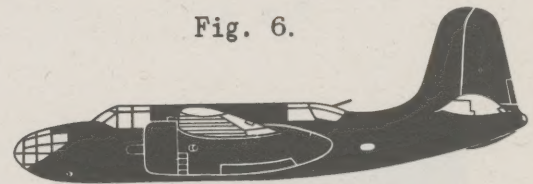


Fig. 6.

usually need **Three View Drawing** to see many of the details. Aircraft workers need to be able to "read" these **Three View Drawings**.

Now if we walk around to the side of the plane, we get a picture of it as shown in **fig. 6**. We can see the shape of the rudder and the shape of the fuselage, as viewed from the side.

THE THREE VIEWS OF A DRAWING



Fig. 7

PICTURE DRAWING



Fig. 8.

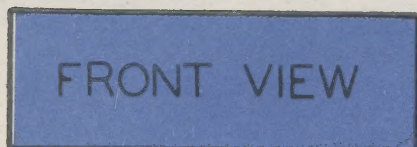


Fig. 9.



Fig. 10.

VIEWS OF A THREE VIEW DRAWING

To make it easier to understand, the different views are labeled TOP VIEW, FRONT VIEW AND RIGHT-SIDE VIEW. On regular drawings used in Air Depots the labels are omitted.

To understand how to go about the reading of aircraft drawings, let us start with a drawing of a very simple object. Fig. 7 is a sketch or picture drawing of a small block of wood, about the size and shape of a box of safety matches, shown as it would look when resting on a table. Let us see what a Three View Drawing of this block would look like when viewed from its various sides.

If you were to look directly down on the block, you would see the outline shown in fig. 8. This is known as the top view. From this view you cannot tell how high the block is, but you do get an idea of its shape as viewed from the top. You can see the four edges at the top of the block, but no more. To get a more complete picture of the block you will need to look at it from other points of view.

When looked at from the front, the block appears as shown in fig. 9. This is known as the front view. This view shows the length and the height of the block.

When seen from the right-hand side, the block appears as in fig. 10. This is known as the right side view. In this view you see both the height and the width of depth of the block.

THE THREE VIEWS OF A DRAWING

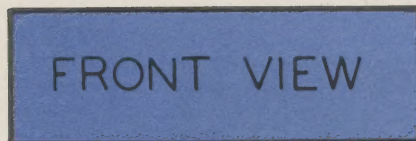
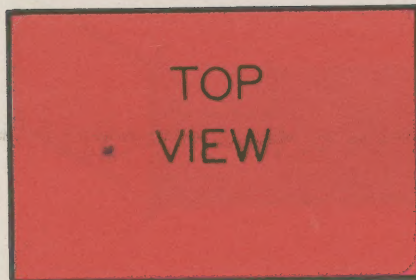
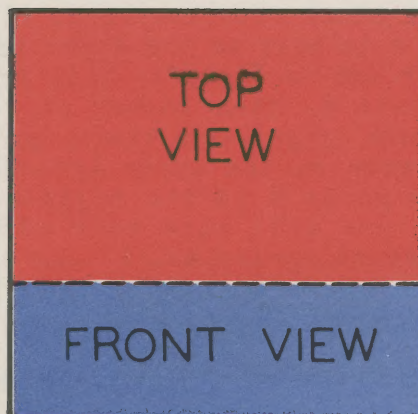


Fig. 11.



In a Three View Drawing, the different views are always lined up accurately. If you were to take a ruler and lay it along the top and bottom lines of the front view, you would find that it lines up with the top and bottom lines of the right-side view. Also, the lines at the left and right sides of the top view line up with the left and right sides of the front view.



Fig. 12.

To make sure that you understand the position of the different views, take a piece of transparent paper and trace or copy fig. 12. Cut the tracing paper on the solid lines; fold the top view back on the broken line, and the right-side view back on the broken line.

You should now have three sides of the box in such a position that you can readily see the size and shape of the box itself. You will find it helpful in making a mental picture of any object represented in a Three View Drawing if you imagine how these views would look when folded together in this way.

LOCATING THE CORNERS

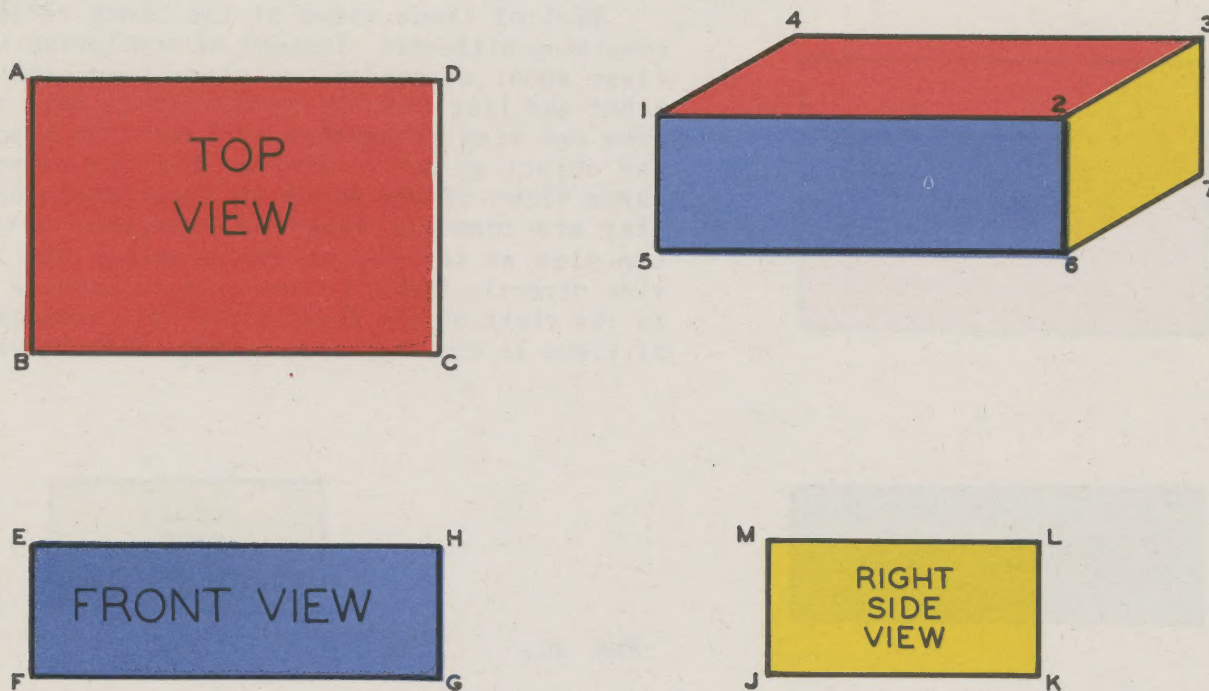


Fig. 13.

Thus far we have been studying the location of the three views usually found in drawings. Now let us see if we can locate the corners of the block on the three views of the drawing. On the block shown in fig. 13, the corners which you can see are numbered from 1 to 7. Each of these corners is found somewhere on each of the three views of the Three View Drawing. Let us look first at corner No. 1, and see where this corner is located in the different views.

When you look down on the block (top view, corner No. 1 is seen to be the lower left-hand corner, and is shown in this top view as point B. When you

look at the block from the front view, corner No. 1 is seen as the upper left-hand corner and is shown in this front view as point E. When looked at from the right side (right-side view), corner No. 1 is shown as the upper left-hand corner, or point M in the right-side view. Here you will note that corner No. 1 is behind corner No. 2, and both corners are shown by point M in this right-side view.

Now look for corner No. 2 in the three views. In the top view it is shown as point C. In the front view it is shown as point H. In the right-side view it is shown as point M.



Some practice in finding these various corners will help you to understand thoroughly how they are shown in the three views of the drawing. Study the sketch and the drawing carefully. Mark in the proper

spaces in the table the *letters* on each of the three views which show the position of the different corners. Go over the sample given of corner No. 1, and then fill in the rest of the table.

TABLE 1

CORNER NUMBERS	POINT WHERE THE CORNER IS SHOWN		
	TOP VIEW	FRONT VIEW	RIGHT SIDE VIEW
1	B	E	M
2			
3			
4			
5			
6			
7			

LOCATING THE EDGES

So far we have studied the location of the corners of the block in the three views of the drawing. Now let us see if we can locate edges of the block in the three views, and learn what these *edges* look like in the drawing.

Refer to fig. 13 and find the edge marked 1-2 on the block. When you look down on the block (top view) this edge appears on the drawing as a line, B-C. When you look at the block from the front (front view) this edge is shown as the line E-H. But when you look at the block from the right side, (right-side view), this edge does not appear as a line, but as a *point* M.

NOTE: When you look directly at the end of an edge, you see the end view of a line, which is a point (.).

When you look at an edge from any other direction, you see a line (-----).

Sometimes one edge (line) is directly behind another edge (line), and if we look at the block from the top, or front, or side, we see only the edges (lines) nearest us. But these lines represent not only the edges we can see, but also any edges (lines) that are directly behind them. Thus the line E-H in the front view, fig. 14, represents not only the edge (line) 1-2, but also the edge line 4-3.

In the left-hand column of Table II are listed some of the edges on the block shown in the sketch in fig. 14. Study the sketch, and the drawing carefully and mark in the proper spaces the lines or points on the drawing which show these edges. A sample for edge No. 1-2 is shown to help you get started correctly.

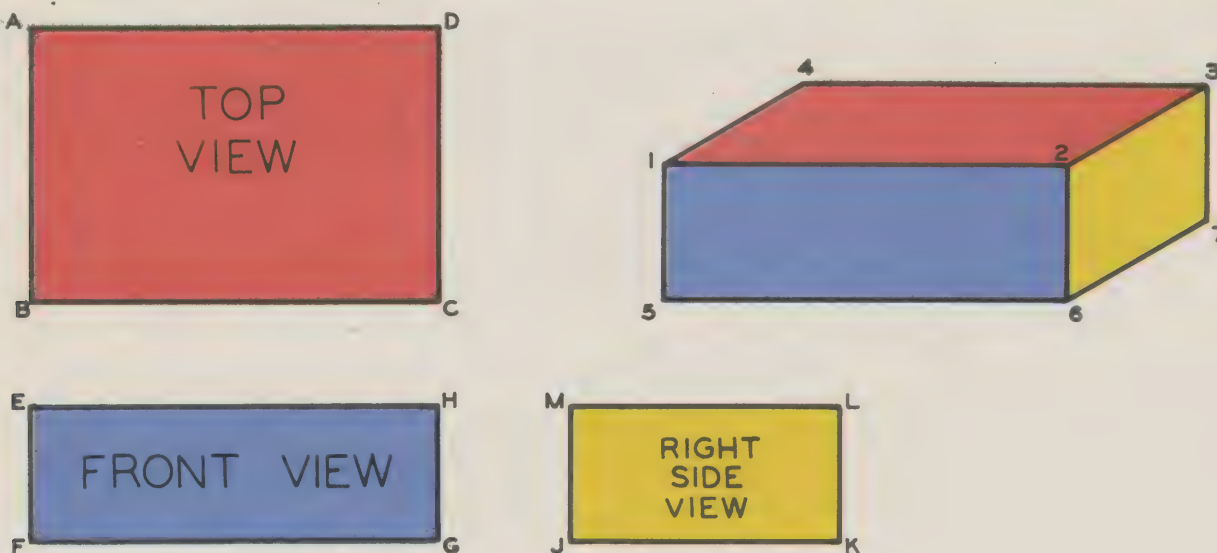


Fig. 14.

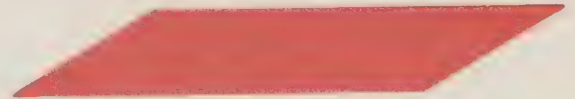
TABLE II

EDGE NUMBERS	HOW THE EDGES ARE SHOWN IN THE DIFFERENT VIEWS		
	TOP VIEW	FRONT VIEW	RIGHT SIDE VIEW
1 - 2	LINE B - C	LINE E - H	POINT M
2 - 3			
1 - 5			
2 - 6			
5 - 6			
3 - 7			
1 - 4			
6 - 7			
3 - 4			

LOCATING THE SURFACES

We have seen how the corners and the edges of the block appear in the three views of the drawing. But how are the top, front and side surfaces of the block shown? If we look at the top surface from above the block it appears as a rectangular area. But if we look from the front or the side, it appears as a line.

Take a piece of paper.



Looking down, we see the whole surface.



Looking directly at the long edge, we see a line.



Fig. 15.

In Table III are listed the various surfaces of the block. The spaces for the top surface are already correctly marked in this table. Now, looking back at fig. 14, write the letters in the proper spaces of the table, and show whether these letters refer to a line or a surface of the block.

TABLE III

SURFACES	HOW THE SURFACES ARE SHOWN IN THE DIFFERENT VIEWS		
	TOP VIEW	FRONT VIEW	RIGHT SIDE VIEW
TOP	SURFACE ABCD	LINE E-H	LINE M-L
FRONT			
RIGHT SIDE			
LEFT SIDE			
BACK			
BOTTOM			

Suppose that the block, fig. 14, were composed of two triangular shaped blocks, as shown in fig. 16. Let us see what the drawings for each of these two blocks would look like.

Fig. 17 shows a Three View Drawing of the block marked A, in fig. 16. When you compare this drawing with the drawing of the rectangular block, fig. 14, you will notice that the front views and the side views are the same in both drawings, but the top views are different. Fig. 17 shows the triangular shape of the top of block A.

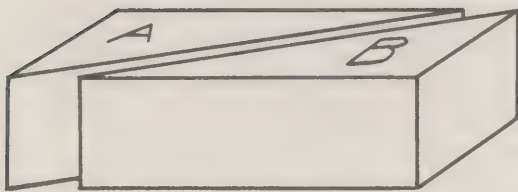


Fig. 16.

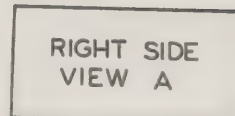
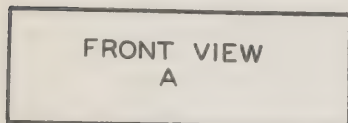
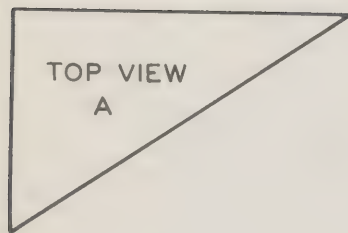


Fig. 17.

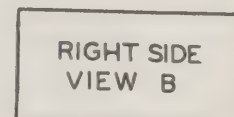
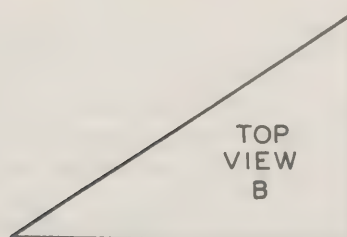


Fig. 19.

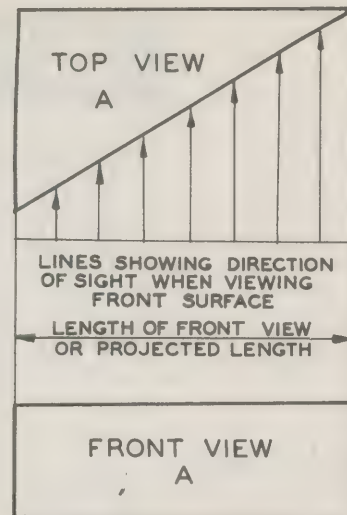


Fig. 18.

Perhaps you may wonder why the diagonal face of the block A, which is longer than either of the other two faces, is not shown in its true length in either the front view or the side view. This is because we see these surfaces only from *directly* in front or from the side. Fig. 18 is a diagram showing the lines of sight when we look at the front of block A, and their relationship to the front view length, or "projected length," as it is called.

In fig. 19 is shown a Three View Drawing of the half of the block marked B. You will note that in this drawing the front and side views are the same as those of the whole block shown in fig. 14. The top view shows how the block is different from that shown in fig. 14, or from the one in fig. 17.

In any *Three View Drawing*, study all the views and imagine how they may be put together, if you want to get a real picture of the object.

LOCATING THE CORNERS AND EDGES

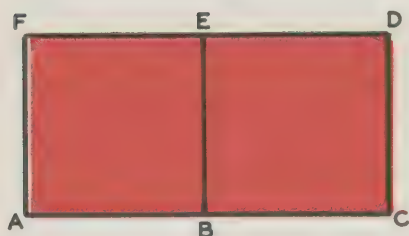


Fig. 20.

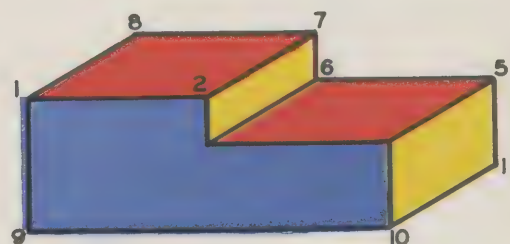
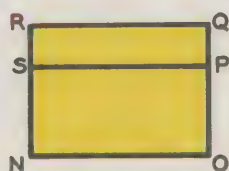


Fig. 20 shows a sketch of a block with a portion of it cut away, and a Three View Drawing of that block.

Study the sketch and the drawing carefully and fill in the tables shown below, indicating how the corners and the edges of the block are shown in the different views of the drawing.

TABLE IV

CORNER NUMBERS	POINT WHERE THE CORNER IS SHOWN		
	TOP VIEW	FRONT VIEW	RIGHT SIDE VIEW
1			
2			
3			
4			
6			
7			
8			

EDGE NUMBERS	HOW THE EDGES ARE SHOWN IN THE DIFFERENT VIEWS		
	TOP VIEW	FRONT VIEW	RIGHT SIDE VIEW
1-2			
3-6			
1-8			
4-5			
3-4			
2-7			
2-3			

THE HIDDEN LINE

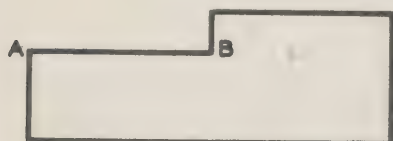
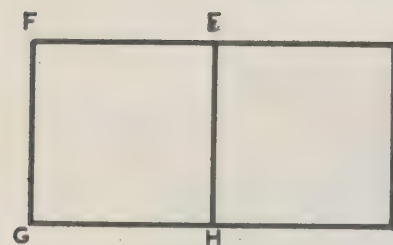
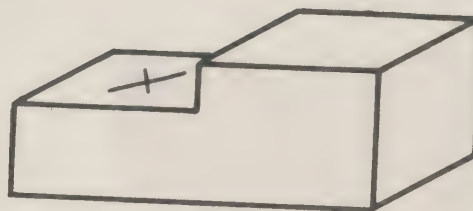


Fig. 21.



Study carefully fig. 21 and you will note that in the right-side view of the drawing there is one broken line (----) C-D.

This kind of line, called a **hidden line**, is used in drawings to show edges or other outlines which are hidden from view. In fig. 21 the surface shown at X in the sketch is represented in the top view of the drawing by the area EFGH. In the front view this surface is visible, and is represented by the solid line A-B. When we look at the block from the right side, we cannot see this surface because it is hidden above it. Since we need to show that

by that part of the block which extends it is there even though we cannot see it, we use the broken line (----) to show its existence and location in the right-side view, line C-D.

Broken lines are used to show the location of holes which cannot be seen in certain of the views of a drawing. In fig. 22 is shown a sketch and Three View Drawing of a block which has a hole through it from top to bottom. This hole can be seen readily in the top view, but is hidden when we look at the block from the front side. So we use broken lines in each of these views to indicate the position of the hole.

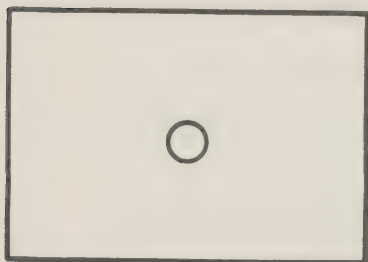
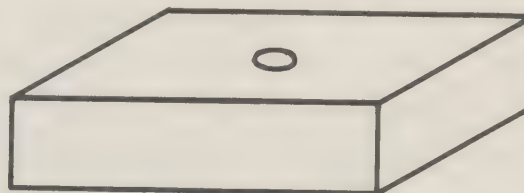


Fig. 22.



TWO VIEW DRAWINGS

Sometimes it is not necessary to use three views in a drawing to show all the details. For some symmetrical objects, two views of the drawing would be exactly alike. For example, in the drawing of the short shaft in fig. 23, the top view is exactly the same as the front view.

When two views will give all the information needed, only two views are shown. The two views we should use in fig. 23 are the front and right side view, leaving out the top view.

In fig. 23 you will see a type of line which has not been used in previous drawings. This line is made up of long and short dashes (— · — · — ·), known as a **center line**. It is most often used to show the location of centers, of round parts or holes, but can also be used to show the center of any object or part of an object.

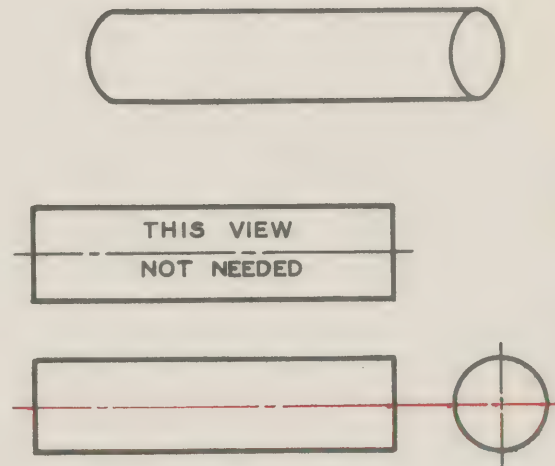


Fig. 23.

ONE VIEW DRAWINGS

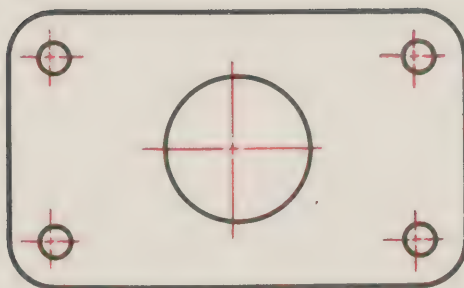


PLATE $\frac{3}{32}$ THICK

Fig. 24.

In making up drawings of flat pieces, especially when these are of relatively thin sheet metal, it is common practice to use only one view. The thickness of the material is then noted on the drawing. Fig. 24 shows such a drawing. This drawing uses only one view to give all the information needed about the shape of the part.

Note that in this drawing there are four holes near the corners of the part. Each of these holes is shown with center lines. The large hole in the center of this part also has center lines. As we shall find out later, these center lines are often used in showing distances between holes or other dimensions.

Section 2. Dimensions

Up to this time we have discussed size only in general terms. We referred to the "length of the block" or the "height of the block", but in no way was its actual size specified. It is necessary that we become acquainted with the method of indicating, on the drawing, the exact sizes and measurements of the object and the distances between certain points on the object.

Let us consider the Three View Drawing of the block discussed in the preceding section.

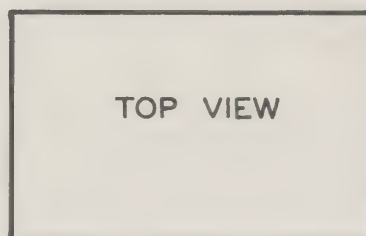


Fig. 25.

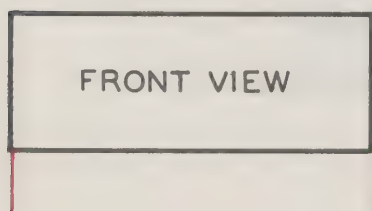
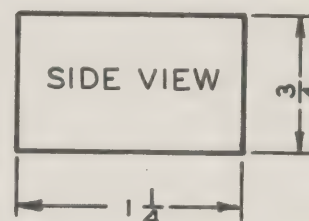
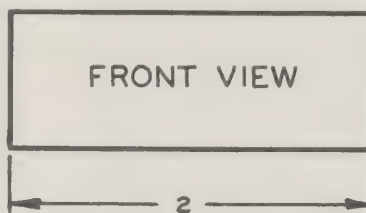


Fig. 26.

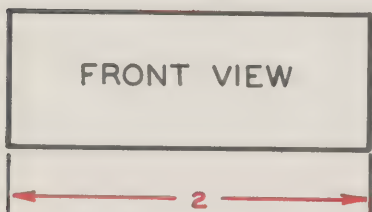
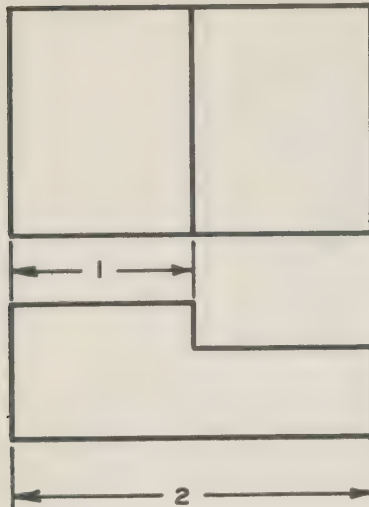


Fig. 27.

The block used is 2" long, 1 $\frac{1}{4}$ " wide, and $\frac{3}{4}$ " in height, depth, or thickness. These dimensions would be shown as in fig. 25. Notice that *in the drawings*, the dimensions are given without using the word "inch" itself, nor ". the usual symbol of inch. Both "inch" and the symbol are usually omitted on aircraft drawings.

In fig. 26 we have repeated the front view as shown in fig. 25. The two lines shown are known as **extension lines**. They indicate the distance measured when the dimension is placed outside the figure to be measured.

The next line of importance is the **dimension line**. Fig. 27 shows this dimension line drawn between the two extension lines. This line has an arrowhead on each end, which shows the direction and the limit of the measurement. In fig. 27. the dimension 2 is the distance across, or the length of the front view.



Now let us consider a more complicated block such as was used in fig. 20. This block has the same general dimensions as the block in fig. 25. The difference is that a portion of the block has been cut away. See fig. 28.

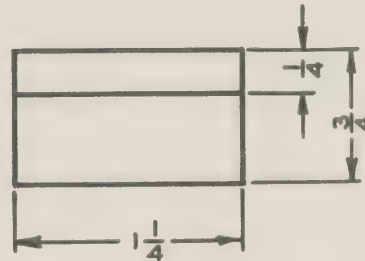


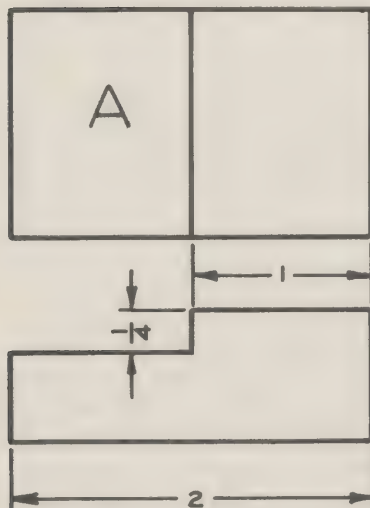
Fig. 28.

If we examine the three views of fig. 28, we will see that the length of the block is 2" (shown at the bottom of the front view). The width of the block is $1\frac{1}{4}$ " (shown below the side view), and the height of the block is $\frac{3}{4}$ " (shown to the extreme right of the side view).

the front view and gives the distance from the left edge of the block to the cut line. This cut line marks the beginning of that portion of the block which was removed. The depth of the cut is $\frac{1}{4}$ " and is shown to the right of the side view.

The information concerning that portion of the block cut away is shown by the dimension 1 which is found at the top of

If the cutaway portion of the block as shown in fig. 28 is reversed as shown in fig. 29, the problem of dimensioning is changed somewhat.



Upon examining the three views of fig. 29, it will be noticed in the side view that the surface A is not visible, but its location is shown by a short dash or broken line. Since it is not considered good practice to dimension "hidden" lines, we have to place the dimension concerning the depth of the cut somewhere else on the drawing. For this reason the dimension $\frac{1}{4}$ has been placed on the upper part of the front view as shown in fig. 29.

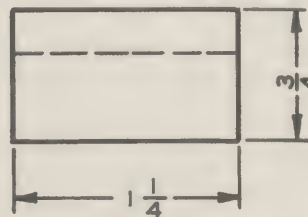


Fig. 29.



Often the space to be dimensioned is too small to contain the figure and the dimension line. It is then necessary to reverse the arrowheads as shown in fig. 30. The dimension figures may be between the extension lines or at one side, depending on the space available. In dimensioning height of the side view in fig. 31, there is enough room between the extension lines for a dimension line, its arrows, and the required dimension.

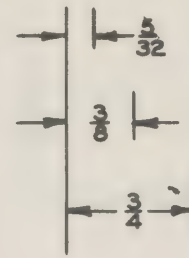


Fig. 30.

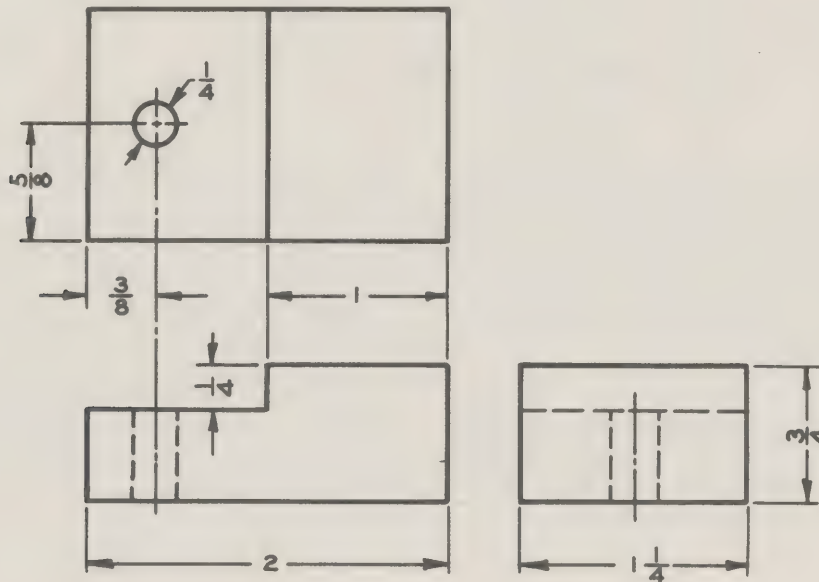


Fig. 31.

If the same block shown in fig. 29 is to have a hole drilled through it as pictured in fig. 31, it will be necessary to dimension the hole so that its exact location and size can be determined.

In studying the drawings in fig. 31, notice that the top view is the only one of the three views where you can see the outline of the hole. In both of the other views the hole is in such a position as to be visible or hidden, and must be shown with short dash lines. As it is usually less desirable to dimension from hidden lines, we find it necessary, on this drawing, to dimension and locate the hole on the top view.

Notice that the center lines pass through the center of the hole and extend outside the block to be used as extension

lines. We are now able to determine that the center of the hole is $\frac{3}{8}$ " from the left side or end of the block, and $\frac{5}{8}$ " in from the front face. The size of the hole usually called the diameter, is indicated on the top view by the two arrows at the circle, opposite each other and labeled $\frac{1}{4}$ ".

Let us suppose that one of the edges of the block shown in fig. 31 is to be rounded. By inspection of fig. 32, you can see that the upper edge of the right-hand end has been cut away to a rounded surface. It is important that the exact location and size of this rounded surface be dimensioned.

Notice that the rounded edge is evident only in the front view. The top and side views have not changed in appearance from those corresponding views in fig. 31.

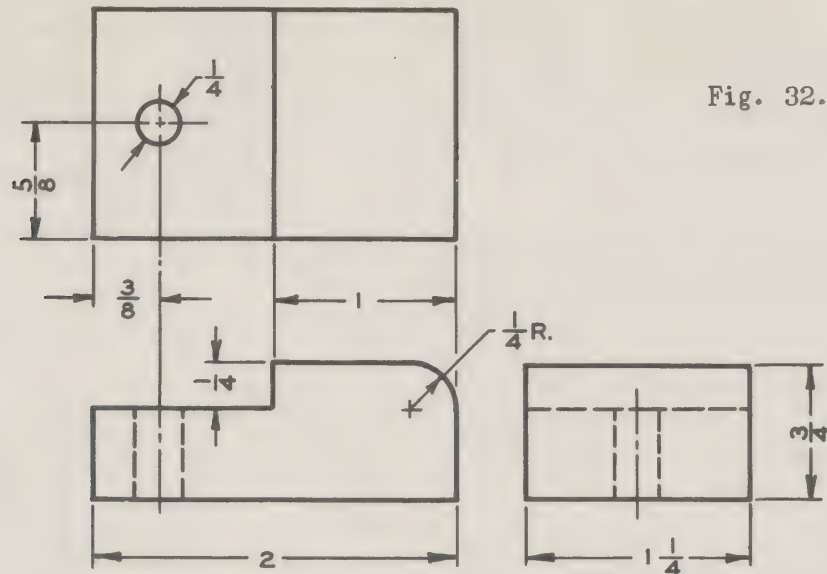


Fig. 32.

You can readily see that the most convenient place to dimension the size and location of the rounded surface is on the front view.

The center of the arc or part of a circle forming the rounded edge is indicated by a $+$. Sometimes a small o is used in place of the $+$. The dimension line showing the radius (the distance from the center to the circle or arc) has one arrowhead. Because the space for showing the radius is small, the dimension line is extended outside the arc and labeled $\frac{1}{4} R.$, which means a radius of $\frac{1}{4}$ ".

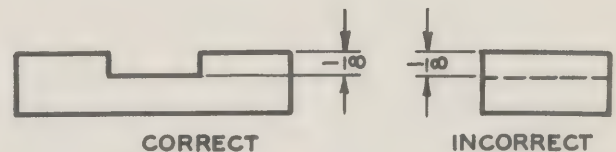


Fig. 33.

The various dimensions discussed in the preceding paragraphs are those most common to practically every drawing. In order to increase your ability to read aircraft drawings, you may need to learn other variations of these dimension types which must be used for special conditions.

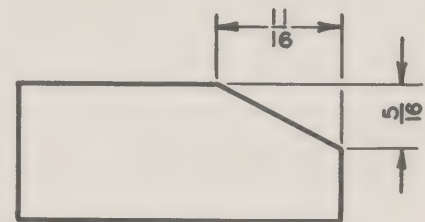


Fig. 34

Dimensions are usually given from visible lines rather than from hidden lines. See fig. 33.

When it is necessary that extension or dimension lines cross each other, you will find that one of the lines will be broken where they intersect. See figs. 34 and 35.

In order to avoid crowding about a center line, dimensions are very often staggered, as shown in fig. 35. It is common practice to dimension parts from a center line as shown in fig. 35.

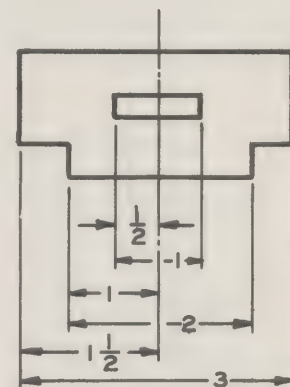


Fig. 35

When a part is too long to be shown completely, the drawing is usually "broken," as indicated by the wavy lines in **fig. 36**. The dimension line, however, is *not* broken, and the dimension specifies the length to make a full-size unbroken object.

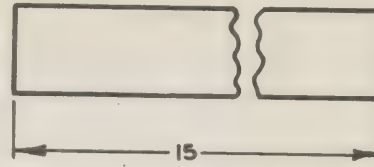


Fig. 36

We have noticed that dimensions are placed outside of all views and to the right and bottom whenever possible. Usually dimensions are so placed that they can be read from the lower edge of the drawing, as in **fig. 36**. Many dimensions, however, are placed so that they are read from the right of the drawing or from other positions.

Dimensions of diameters are often conveniently shown in a slant line, **fig. 37**. Notice that in this figure, the dimension $1\frac{1}{4}$ " is placed horizontally, even though the dimension line is slanting.

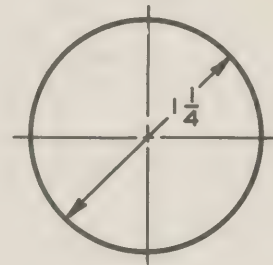


Fig. 37.

Whenever the dimension figures might run into each other, they should be written following the direction of the dimension line. In **fig. 38**, where the dimension $1\frac{1}{2}$ does not interfere with any other dimensions, it may be placed so as to read from the lower edge of the drawing. But in **fig. 39**, there are several dimension lines which are vertical and run alongside each other. In order to avoid misunderstanding, the dimension figures of $1\frac{1}{4}$, and $\frac{1}{2}$ are written in the same direction as these vertical dimension lines.

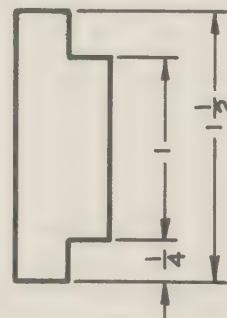


Fig. 39.



Fig: 38.

Where we have a whole series of dimensions (consecutive dimensions), the usual procedure is to place them in a continuous line, as in **fig. 40**. In crowded conditions, the dimensions may be staggered. Notice in **fig. 41** that the dimensions are alternately above and below one another making it possible to read them more easily.

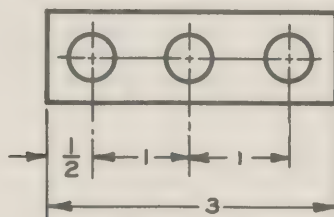


Fig. 40

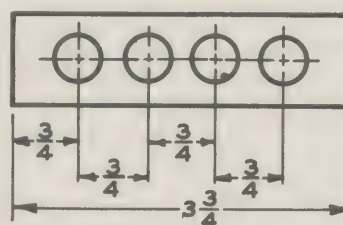


Fig. 41

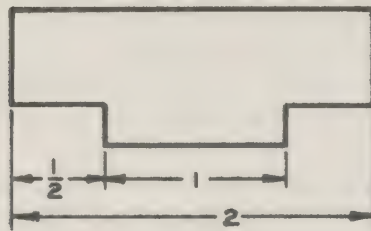


Fig. 42.

Notice that there is a space left which is not dimensioned in several of the preceding drawings. When making parts, you are allowed a limited variation or error, but you should make your measurements on the object between points which are dimensioned on the drawing.

For example, suppose you were making the object shown in fig. 42. if you make the notch a little longer within allowable limits than the one-half inch called for in the drawing, and the center section slightly longer than the one inch specified, then both of these errors are intended to accumulate in the undimensioned space. The points requiring the greatest accuracy are dimensioned, and the allowable variations are expected to accumulate in the undimensioned spaces.

Progressive dimensioning, often used on machine parts and small drawings, always starts from a common base line or extension line as shown as A in fig. 43. In progressive dimensioning, it is common practice to use a separate dimension line for each dimension.

Dimensions of parts that can be measured or that can be produced with sufficient

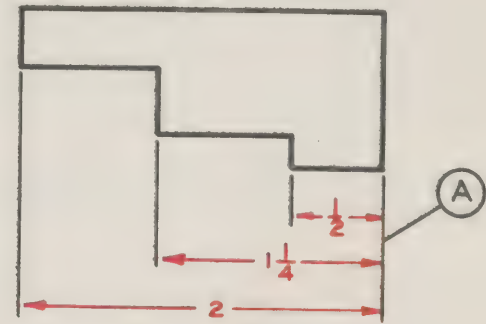


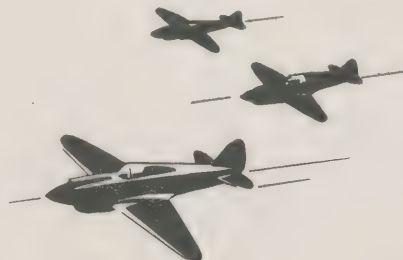
Fig. 43.

accuracy by using an ordinary scale should be written in whole numbers and common fractions. Up to this point in our discussion of dimensions, we have used only whole numbers and fractions such as three and one-quarter inches, written on the drawing as $3\frac{1}{4}$.

The fractional divisions of an inch are found by dividing the inch into equal parts. The fractions used in aircraft drawings are: halves, quarters, eighths, sixteenths, thirty-seconds and sixty-fourths.

When smaller units of measurement are required for greater accuracy, the decimal system is used in which the *inch* is divided into tenths, hundredths, thousandths, ten-thousandths and hundred-thousandths. One-half is expressed as .5 (five tenths), $\frac{1}{4}$ as .25 (twenty-five hundredths), $\frac{1}{8}$ as .125 (one hundred twenty-five thousandths).

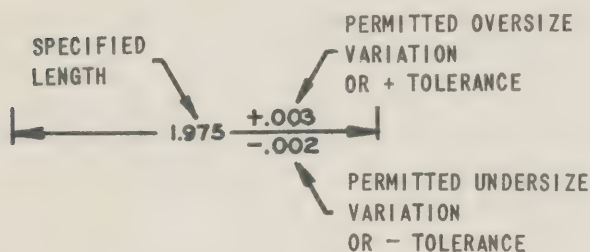
Sometimes a dimension that could be read as a tenth or a hundredth will have one or two zeros added so that it will read as a thousandth. For example, .5 (five tenths) might be written as .500 (five hundred thousandths). The value of the two decimals is exactly the same: $.5 = 5/10 = \frac{1}{2}$, and $.500 = 500/1000 = 5/10 = \frac{1}{2}$.



Although a table top might vary by one-sixteenth of an inch, such inaccuracy in most aircraft work would not pass inspection. The amount of variation permitted is usually indicated on the drawing.

The variation may be expressed as **tolerances**, or in the form of **limits**.

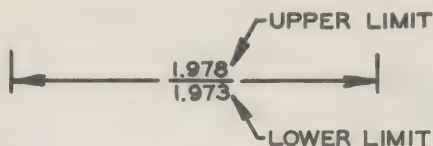
For example, in the following dimension the permitted variation is given in the form of tolerances:



The $+.003$ " after the specified size means that the object is allowed to measure up to $.003$ " (three thousandths of an inch) over specified size, or oversize. Hence the greatest acceptable length is 1.975 " $.003$ ", or 1.978 ".

The $-.002$ after the dimension tells us that the piece is acceptable if it is as much as $.002$ " (two thousandths of an inch) undersize, or shorter than the specified size. In other words, the shortest length that is acceptable is 1.975 " minus $.002$ ", or 1.973 " long.

Acceptable variations are often expressed in the form of limits. The same variation expressed as tolerances in the previous example appears as follows when expressed in the form of limits:



1.978 " is the upper limit of acceptable variation.

1.973 " is the lower limit of acceptable variation.

Some plants use the system of placing the upper limit above the line for outside measurements, as in **fig. 44**, and of putting the lower limit above the line for holes and inside measurements, as in **fig 45**.

Tolerances also apply to the use of fractions in measurements. This tolerance or limit is shown by a note on the drawing, explaining for that particular drawing the fractional part of an inch allowed for tolerance. For example, the note might read: Tolerance $\pm 1/64$ ", meaning that a dimension might vary $1/64$ " more or less from the dimension given and still be acceptable.

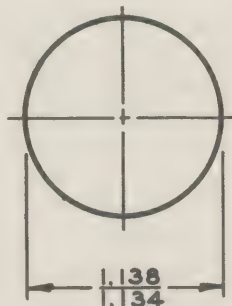


Fig. 44.

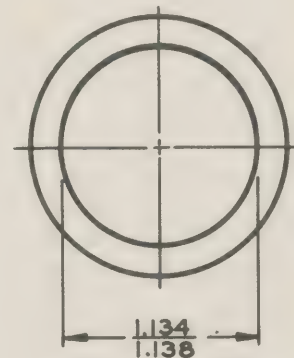


Fig. 45.

In general, **angles** are dimensioned with an arc or part of a circle used as the dimension line. Small angles, such as a fifteen degree angle (15°) would probably be dimensioned as in **fig. 46**. Notice that the number 15 is placed horizontally and that the arrows, dimension line and number are outside the angle.

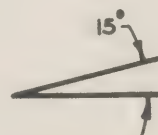


Fig. 46.

If the angle has a greater spread, or the space between the lines is greater, such as an angle of 30° , it might be dimensioned as in fig. 47. In this illustration you will find that the dimension line, arrows and number are inside the angle.



Fig. 47.

Sometimes large angles are dimensioned with the number of degrees so placed that it follows the direction of the dimension line arc. For example, if we have an angle of 110° , it would usually be dimensioned as in fig. 48.



Fig. 48.

Angles are not always measured in even degrees. Sometimes you will notice angles measured in degrees plus parts of a degree (minutes). See fig. 49. A degree is divided into sixty equal parts, each one called a minute, and the minute is designated by the mark ('). For example, $46^\circ 12'$ would be read as 46 degrees and 12 minutes, and would appear on a drawing as shown in the illustration.



Fig. 49.



Fig. 50

By comparing fig. 37 with fig. 50 you will see that there are two ways of dimensioning the diameter of a circle. Both methods are used at the present time. There is a trend, however, towards making all dimensions read from the bottom of the page.

Small circles are often measured by a dimension line and its arrowheads placed outside the limits of the circle and with the dimension figure also outside the line of the circle, as in fig. 51.



Fig. 51.

If a part of a circle or arc is to be dimensioned, the size will usually be indicated by the use of a radius dimension (a line drawn from the center point to the circle or arc). The dimension figure is usually followed by the letter R., the abbreviation for radius. See fig. 52.



Fig. 52.

If the length of the radius will permit, the arrowhead, abbreviation and dimension will be shown as in fig. 52.

In smaller arcs or parts of circles, the dimension and abbreviation may be outside of the arc. In some cases the arrowhead may also be outside. See fig. 53.

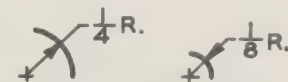


Fig. 53.

Holes in parts are frequently dimensioned by giving, in the form of a note, the size of the tool used in making the hole. See fig. 54.



Fig. 54

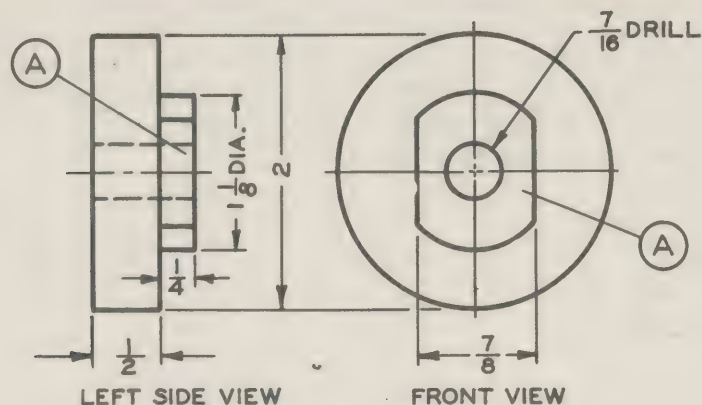


Fig. 55.

Many cases are found where a dimension indicating a size of a round part is in such a location on the drawing that its meaning is not clear. These dimensions are usually followed by the abbreviation D. or DIA. (diameter) in order to indicate that the dimension so labeled is a diameter. See fig. 55.

In fig. 55 you will notice in the LEFT-SIDE VIEW that the two-inch dimension refers to the same extension lines that go to the large circle in the front view. The diameter, or distance across the large circle, is seen to be two inches and is so clear that the abbreviation DIA. is often eliminated.

The dimension 1-1/8 DIA., also found in the LEFT-SIDE VIEW, fig. 55, gives the diameter of the rounded section of the

part labeled A. As a dimension, its relationship to the part A in the front view is not easy to see, so that dimensions of this kind are usually labeled with the abbreviation DIA. We are thereby informed that in the LEFT-SIDE VIEW, the lines referred to by the dimension 1-1/8 DIA. are lines of a circular part whose diameter is 1-1/8".

On some drawings, the parts of circles or arcs are so large that their centers cannot be shown on the drawing itself. Fig. 56 is a drawing representing a sheet of paper. On this paper is drawn an arc whose radius is 25". In drawing this arc, it was necessary to locate the center *off the paper*. The part of the radius line shown *on the paper* is "broken" to indicate that the center, or its starting point, is not shown on the drawing.

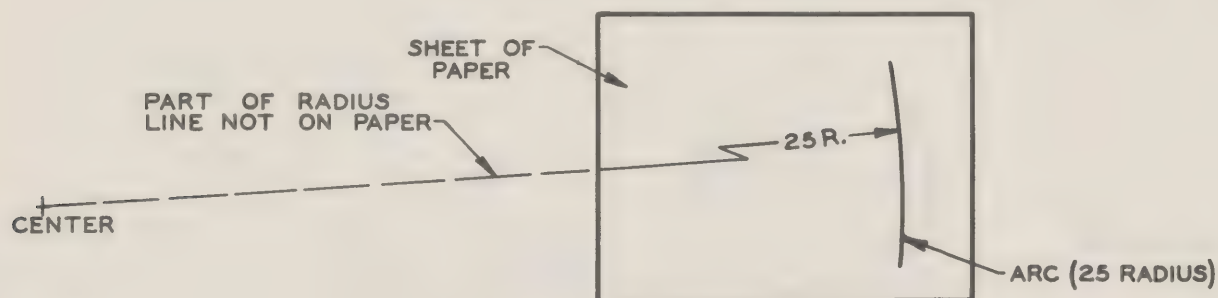


Fig. 56.

Questions

1. What is the difference between an extension line and a dimension line?
2. In a shop where a tolerance of $\pm 1/64$ " is allowed on fractional dimensions, what would be the upper and lower limits for the size of a part dimensioned $3\frac{1}{2}$ "?
3. Why are dimension figures sometimes placed outside extension lines rather than between them?
4. When dimension lines cross each other, how are they usually drawn?
5. Where are staggered dimensions frequently used?
6. If a part on a drawing is too large to be drawn at its full length and is shown broken, what happens to the dimension lines of that part?
7. What is meant by "progressive dimensioning?"
8. What are the common fractional divisions of an inch used in aircraft drawings?
9. Find the upper and lower limits for the following dimensions: $3" \pm 1/64$; $3.000" \pm \begin{smallmatrix} .005 \\ .000 \end{smallmatrix}$; $3.000 \pm \begin{smallmatrix} .002 \\ .002 \end{smallmatrix}$.
10. What do you mean by the terms "limit" and "tolerance?"
11. In dimensioning holes, what information is often given?
12. When is it necessary to "break" a radius line?
13. Dimensions of diameters or radii are sometimes followed by the abbreviation D., DIA., R. or RAD. When is this necessary?

Section 3. Notes

Notes, as well as dimensions, make clear the meaning of an aircraft drawing. Some items of information, which cannot be given conveniently in the dimensions of drawings, are put into notes.

These notes give us such information as the kinds of material to be used, the order of working procedures for manufacture or assembly, the tools to be used to produce the required results, the type of finish desired, the name of the department which is to perform certain work on the part, and many other useful details.

In general, notes give information and instructions that cannot be illustrated on the drawing. Notes, as a rule, should not repeat information that is easy to find elsewhere on the drawing.

In this section are some typical examples of notes on aircraft drawings. There are others, of course, which are so abbreviated and so technical that understanding them requires special knowledge and training in certain technical fields. One generally accepted type of note is used in fig. 57.

The note tells the *number of the drill* to be used, the *size of the holes*, the *number of holes required* and the *spacing of the holes*. The size or number of the

drill is shown by "#30." In parenthesis we see ".128" which is the exact *measured diameter of the drill* required to make these holes. The note then tells us that there are "10" holes. We find out about the *spacing of the centers of the holes* by the note "EQUALLY SPACED" which saves the placing of nine separate dimensions on the drawing.

As some of the following illustrations show, the work to be done on a small part is difficult to dimension clearly. Often the explanation of the work to be done can be clearly explained by a simple note.

The following illustration, fig. 58 shows a chamfer or beveled edge to be machined on the end of a round, metal rod.

The note on the drawing at the left is the usual way of describing the surface designated by the arrowhead. This surface is to be chamfered (beveled). The length of the chamfer is to be ".0625", and the angle that the chamfered surface makes with a horizontal line, or with the surface of the rod, is 45° .

The enlarged view on the right shows the dimensions that would be necessary if the note were not there.

Fig. 57.

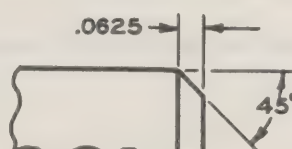
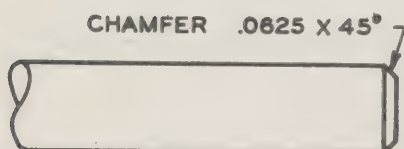
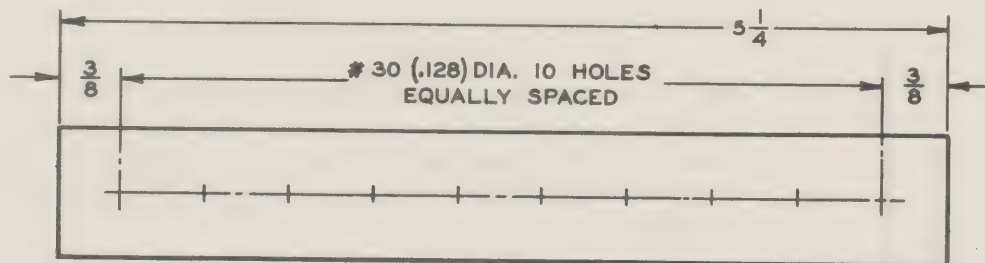


Fig. 58.

Frequently, drawings are made to illustrate the assembly or disassembly of parts. Fig. 59 is a sketch drawing giving instructions for taking apart some particular unit of an airplane. You will notice two notes at the top of the figure telling which nuts and bolts to remove. In white letters is a note quite common on drawings, giving the direction from which the part is viewed. The same note also describes this as the left-hand (L.H.) side and explains that the right-hand (R.H.) side is the opposite of this drawing.

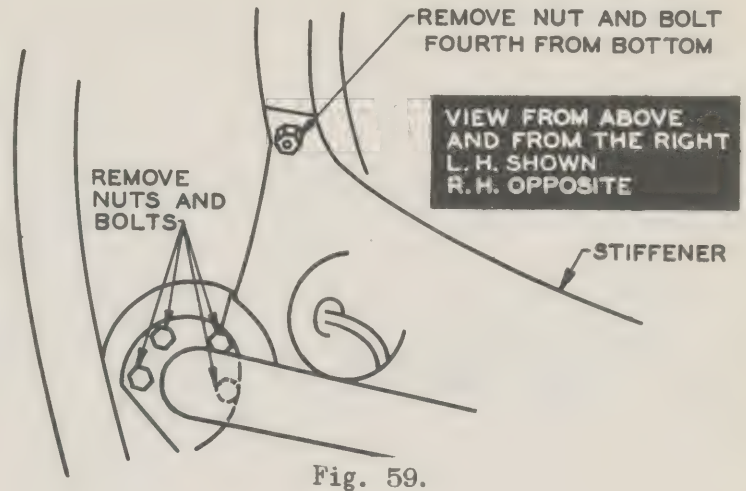


Fig. 59.

Drawings sometimes indicate changes that are necessary in the manufacture or assembly of a part. Fig. 60 shows a drawing of the top view of a box in which the locations of the holes are to be moved $\frac{1}{2}$ " to the right of the present location. The note carefully points out the location of the old holes and the new ones; their relative relation is indicated by the large arrow marked FWD, (FORWARD); and also the number of holes to be moved (4 PLACES).

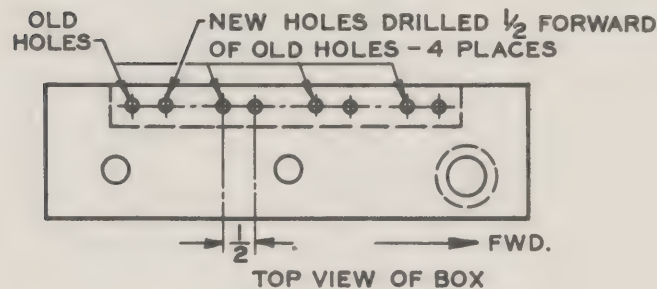


Fig. 60.



- 1 STIFFENER
- 2 RIVETS - $\frac{5}{32}$ DIA. TYPE AN 442 AD
- 3 WEB
- 4 X (JOGGLED OFFSET) EQUALS THREE TIMES THE WEB THICKNESS

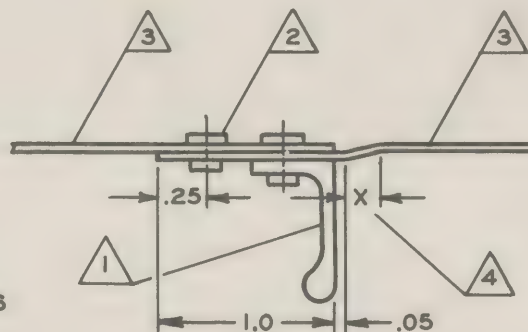
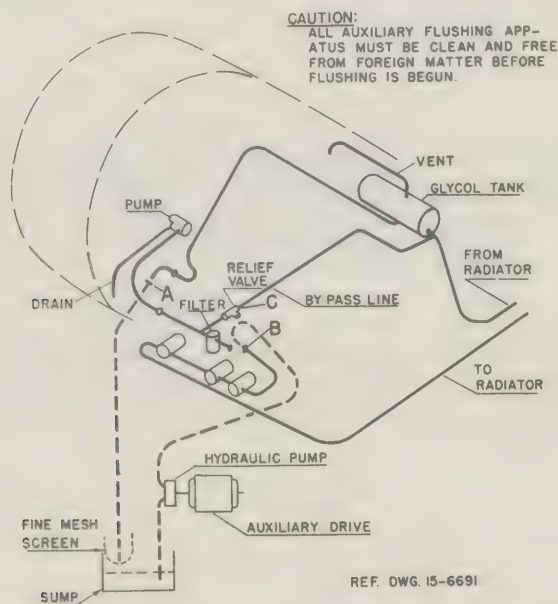


Fig. 61.

It is common practice for draftmen to place notes in the form of a list. Each part requiring a note is numbered or lettered and the note explaining this part is correspondingly numbered or lettered. In fig. 61 you will notice, at the top of the drawing in one of the small triangles, the number 2. The note referring to this part is at the left side of the drawing. This note gives the diameter of the rivets, " $\frac{5}{32}$ " Dia.", and their type, "AN442AD."

The letters AN or AC preceding a code number, which in this note is 442AD, indicate that the parts must meet Army and Navy or Air Corps specifications.

Care, operation, and general maintenance of parts of the airplane are often simplified by the use of diagrams. Fig. 62 is a diagram of a Glycol Cooling System on an airplane, giving the name and location of parts.



1. DISCONNECT FILTER-TO-HEATER LINE AT "A" & "B" AND CONNECT AUXILIARY PUMP AND LINES, AS SHOWN.
2. CLOSE SUPPLY TANK VENT.
3. CIRCULATE HOT WATER FOR SEVERAL MINUTES.
4. DISCONNECT AUXILIARY LINE AND BY PASS LINE AT "C" AND BLOW SYSTEM OUT WITH AIR.
5. CONNECT THE AUXILIARY PUMP AND LINES AND FLUSH THE SYSTEM OUT WITH THE SAME LIQUID TO BE USED FOR OPERATION.
6. REMOVE AND CLEAN THE FILTER.
7. RE-CONNECT SYSTEM AND REFILL (RUN ENGINE TILL LINES ARE FULL AND REPLENISH TANK TO FULL MARK).

Fig. 62.

The notes on the diagram refer to the necessary procedure for flushing the system. The note at the top of the drawing is a *caution note*, explaining the care which must be taken before actually beginning the operations outlined at the bottom of the drawing.

The operation note at the bottom describes the operations or steps to follow in flushing the system. Operations are listed in the order which work is to be done.

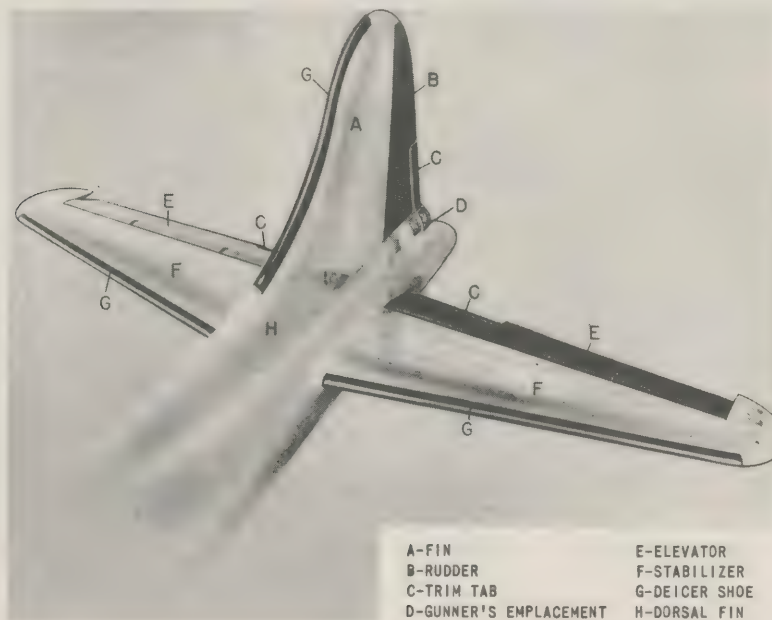


Fig. 63.

Fig. 63 is a photograph of the tail of an airplane. *Small letters* are used as reference keys on the photograph to keep it from being cluttered up with the names of parts. In the lower right-hand corner of the picture, the *actual name of each part is listed after each key letter.*

USE OF NOTES ON SECTIONAL DRAWINGS

Frequently drawings are made to give general information concerning a part or device. It might be advantageous to show the inner construction and action of movable parts by means of a sectional drawing. In section drawings, some of the object has been removed or cut away, and we are able to see the interior of the piece or assembly. On such a drawing, the use of notes or lettering of the various parts simplifies the reading of the drawing.

EXAMPLES OF SECTIONAL DRAWINGS SHOWING THE USE OF NOTES AND LETTERING

NOTES:**1. REFER TO:**

ADEL PRECISION PROD. INC. DRAWING NO. D-9050

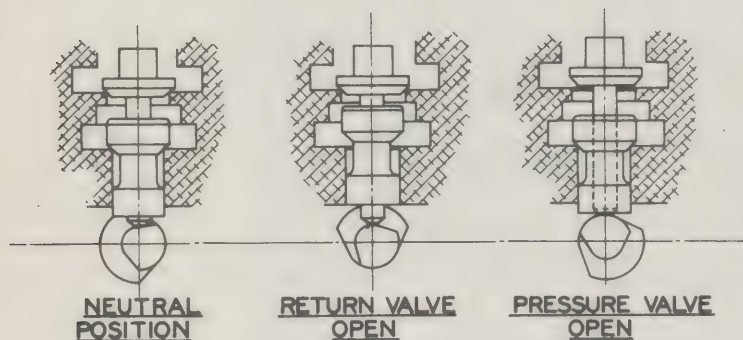
LOCKHEED DRAWING NO. 667135

TEST NOTES:

1. PRESSURE TEST AT 2000 P.S.I. FOR LEAKS

2. PRESSURE TEST AT 10 TO 25 P.S.I. FOR LEAKS

3. WORKING PRESSURE 1000 P.S.I.



LET.	PART NO.	NAME	REQ.
A	AC995-C 40	LOCKWIRE	1
B	A-9101	CAP	2
C	A-9109	SPRING	2
D	S-304A-885-586-0375	WASHER	2
E	A-9104	STEM	2
F	A-9105	LOWER SPRING	2
G	A-9106	SPACER	2
H	A-9107	CUP	2
I	A-9108	STEM	2
J	A-9114	RETAINER	1
K	AC995-C 40	LOCKWIRE	2
L	A-9111	WASHER	1
M	AC 503-8-6	SCREW	4
N	S-9113-A-012	CUP	1
O	A-9112	SPACER	1
P	B-9115	SHAFT	1
Q	G-9117	BODY	1
R	S 303-8A	WASHER	2
S	A-9616	PLUG	2

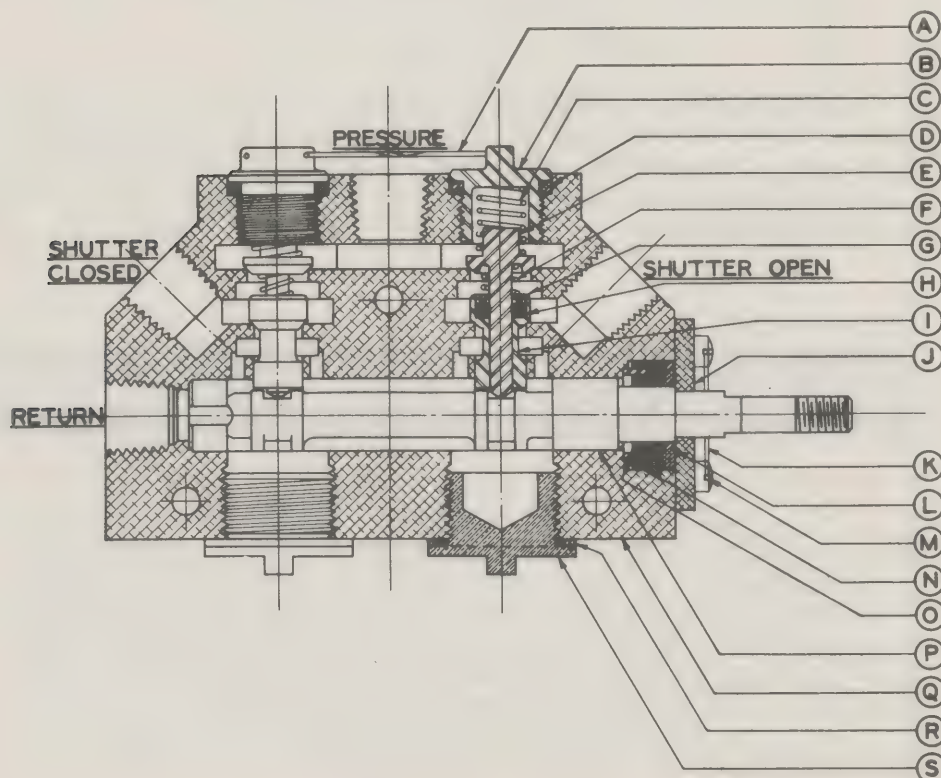


Fig. 64. Prestone Radiator Flap Control Valve.

In fig. 64 you will see such a section, with notes describing the position of important parts, such as "SHUTTER CLOSED" and "SHUTTER OPEN." Near one of the openings you will notice the word "RETURN," signifying that at this point the fluid re-enters the device.

Off to the right of the drawing are a series of letters within circles, each pointing by means of an arrow to a specific part.

At the upper right-hand corner of the page is a table divided into four columns. The first column lists the letters corresponding to the letters on the drawing. The second column designates the proper part

number for each part. The third column names each part, and the fourth column tells us the number of parts necessary to construct the device.

In the upper left-hand corner of the drawing are two types of notes. One is a "Reference Note." Notes of this type are frequently used to tell you where to obtain more detailed information regarding the same device, or any of its parts.

The other note is a "Test Note" describing in detail how to test the device for leakage. The pressure at which the part will normally be required to function is given in item No. 3 as "1000 P.S.I." (pounds per square inch.)

Questions

1. Why are notes used on drawings?
2. How can a note be used to replace certain dimensions on a part?
3. What is a reference key?
4. What is a directional note?
5. What is a test note? Describe a typical example.
6. How are notes used to describe the position of parts?
7. What are reference notes? How are they used?
8. What is a caution note?
9. How are notes used to describe materials?
10. What is an operation note?

Section 4. Lines

In the previous sections of this monograph, we have observed that drawings have various means of giving us desired information. For example, through the use of *dimensions* we are able to tell the size of various parts. With the help of *notes* we find that many important features of a drawing are more clearly explained. Now we come to another element in drawings that is extremely important - the use of *lines* to impart information.

Most drawings make use of three weights or intensities of lines: heavy, medium, and light. See fig. 65.

These lines may vary somewhat on different drawings. As a rule, each drawing will have a *noticeable contrast* between a *heavy* and a *light* line, with the intensity of the medium weight line somewhere *between* that of the heavy and the light lines.

Each type of line has a definite use on a drawing in order to increase the number of ways a line might be used, the *form* of the line is changed. For example, we have already seen that a light line may be broken into a series of long dashes alternating with short dashes.

and we use this type of line as a *center line*.

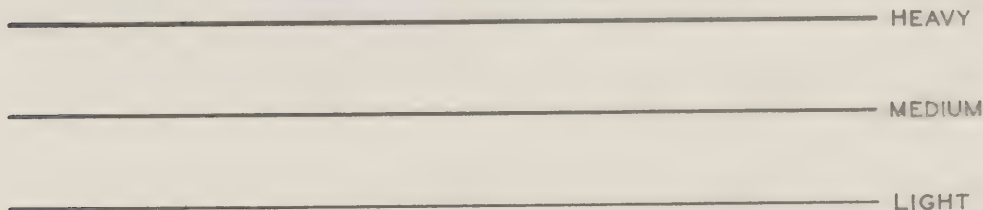


Fig. 65.

To make a study of the various types of lines and compare one with another, the following table, fig. 66, will be found useful.

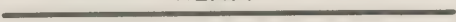
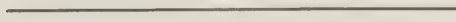
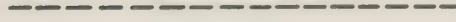
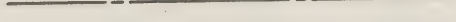
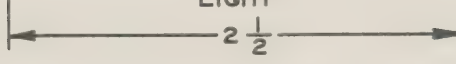
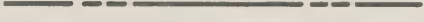
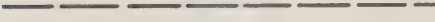
<i>Outline of parts</i>	 HEAVY	The outline should be the outstanding feature and the thickness may vary to suit the size of the drawing.
<i>Section lines</i>	 LIGHT	Spaced evenly to make a shaded effect.
<i>Hidden lines</i>	 MEDIUM	Broken line made up of short dashes.
<i>Center lines</i>	 LIGHT	Broken line, made up of long and short dashes alternately spaced.
<i>Dimension and extension lines.</i>	 LIGHT $2 \frac{1}{2}$	Lines unbroken, except at dimensions.
<i>Cutting plane line</i>	 HEAVY	Broken line made up of one long and two short dashes, alternately spaced.
<i>Break lines</i>	 HEAVY  LIGHT	Freehand wavy line for short breaks. Ruled line with freehand zig-zag for long breaks.
<i>Adjacent parts and alternate position lines</i>	 MEDIUM	Broken line made up of long dashes.

Fig. 66.

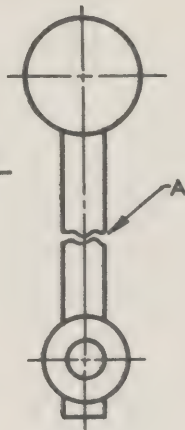
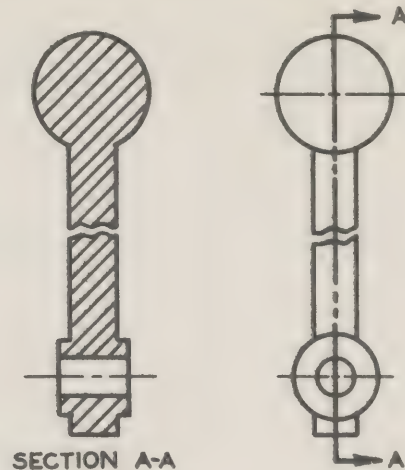
CONTROL
LEVER

Fig. 67.



SECTION A-A

Fig. 68.

The drawing in fig. 67 represents a long, slender part. The central part of the lever is the same shape and size throughout its length. In order to shorten the drawing, most of this central portion has been removed and the ends brought close together. The space between the break lines at point A shows that a portion has been removed.

A heavy weight line, consisting of a series of long dashes alternating with two short dashes, is a cutting plane line. This line is used to show exactly where a part is cut to expose the inside or Cross Sectional View. Fig. 68 shows a cutting plane line drawn through the lever. The arrows A-A show the direction in which the reader would be looking when reading the Section View labeled "Section A-A."

Section A-A is a drawing of the right half of the unshaded drawing as we look at it in the direction in which the arrows point. The left half has been removed, exposing cut metal. The slant lines running through Section A-A are illustrations of section lines or cross hatching. They show where the metal has been cut.

The adjacent part line shown in fig. 69 (in red) shows the position of the part which is next to and important to the control lever or the main object in the drawing.

The adjacent part line is of medium weight and consists of a series of long dashes.

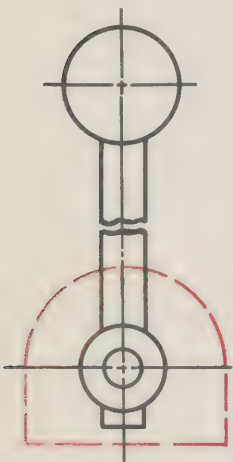


Fig. 69.

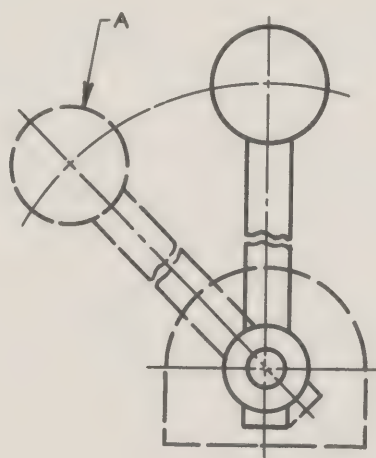


Fig. 70

The alternate position line, fig. 70, is necessary only when the part drawn is a moving part and changes its position. The alternate position line duplicates the outline of that moving part in its various positions. See A in fig. 70.

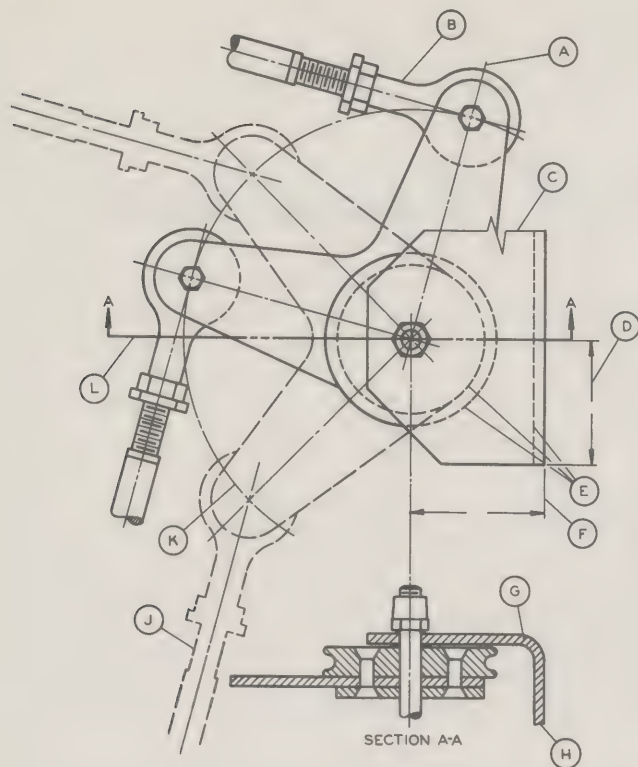


Fig. 71 is an airplane part. It consists of a bracket which supports a double arm. This arm moves from one position to another.

The following table gives a list of letters corresponding to the letters on the drawing.

Study the drawing in fig. 71 and place in the column labeled "NAME OF LINE" the name or kind of line each letter refers to on the drawing. In the column marked "DESCRIPTION" describe the line in detail. The line A has been described for you. Complete the list.

Fig. 71.

TABLE V

LINE	NAME OF LINE	DESCRIPTION
A	CENTER LINE	LIGHT-ALTERNATE LONG AND SHORT DASHES
B		
C		
D		
E		
F		
G		
H		
J		
K		
L		

Section 5. Symbols and Abbreviations

A symbol is a conventional sign such as a *character, letter or abbreviation* used *instead* of a word or words, to represent *operations, quantities, qualities, relations, or position.*

Symbols and abbreviations are used in place of long explanatory notes on drawings. We find that a *few* of these symbols and abbreviations *are common to every trade* and that *special trades have special symbols and abbreviations.*

One of the frequently used symbols, C , stands for center line. Although the symbol C is not necessary when the correct type of center line is drawn, occasionally we see the line and symbol used together, as in fig. 72.

The abbreviation *SYM.*, coming from the word *symmetrical*, is commonly used to indicate that a part is exactly the same on either side of the center line. Fig. 72 is symmetrical about the center line as indicated by the abbreviation *SYM.* placed under the symbol C .

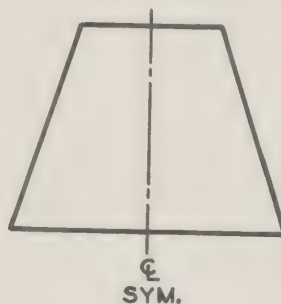


Fig. 72.

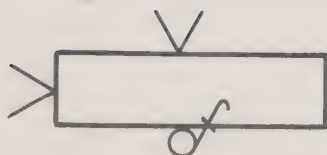


Fig. 73.

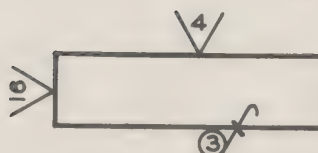


Fig. 74.

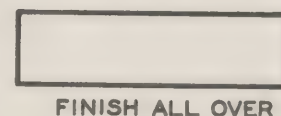


Fig. 75.

A surface on a metal part may be "finished" by performing a machining or hand fitting operation on the surface. Examples of these finishing operations are reaming, lathe turning, shaping, grinding, scraping and file fitting.

The symbol for a finished surface is a ∇ . Correctly drawn, the angle between the two lines of the ∇ is 60° . When a surface is to be finished, a ∇ is placed with the point touching that surface. See fig. 73. Sometimes a letter *f* is used instead of a ∇ to indicate a surface to be finished. (See lower line in fig. 73).

Numbers are placed within the angle of the ∇ to describe the kind of finish to be applied to that particular surface. See fig. 74. In some cases, the lower part of the symbol *f* is looped to form a small circle surrounding a number designating the type of finish, as in fig. 74. If the part is to be finished on all sides, the drawing will be labeled as in fig. 75. The abbreviation *F.A.O.* may be used in place of the words "FINISH ALL AROUND."

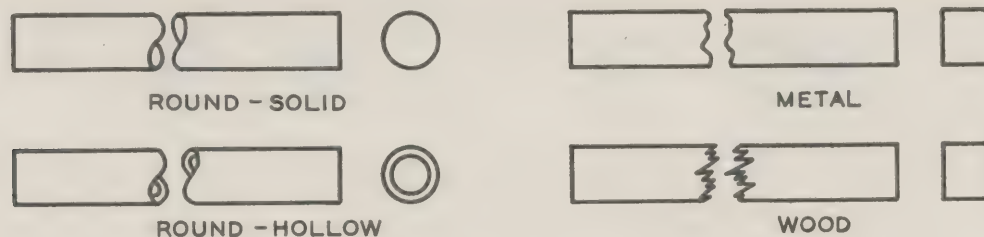


Fig. 76.

In fig. 76 are conventional symbols which help you understand the material and shape of broken parts. On the left side of fig. 76 are the break lines used in shortened views of a shaft (round-solid), and of a pipe (round-hollow). The two symbols in the right half of fig. 76 show break lines for rectangular pieces of metal and of wood.

A few of the more common symbols to be found on drawings are listed below:

Equal is written as =	Center = + or o
Foot = '	Degree = °
Inch = "	Minute = '
Angle = ∠	Second = "

In sectional drawings of parts made of only one kind of material it is common practice to use a simple cross-section line (/////) and to indicate the kind of material in the title block.

Fig. 77 is a sectional drawing of a relief valve where line symbols have been used to indicate the various kinds of materials in the assembly. For example, you can find the arrangement of lines which indicates aluminum alloy by following the arrow to the part made of this material. In a shop where a standard symbol has been set up for each material used, the *names* of materials need not be shown as in fig. 77. This drawing will give you a general idea of the use of drafting symbols for indicating materials.

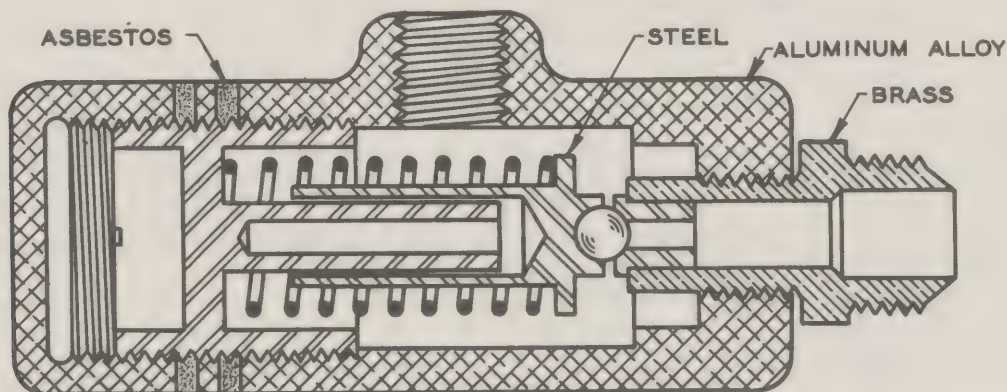


Fig. 77.

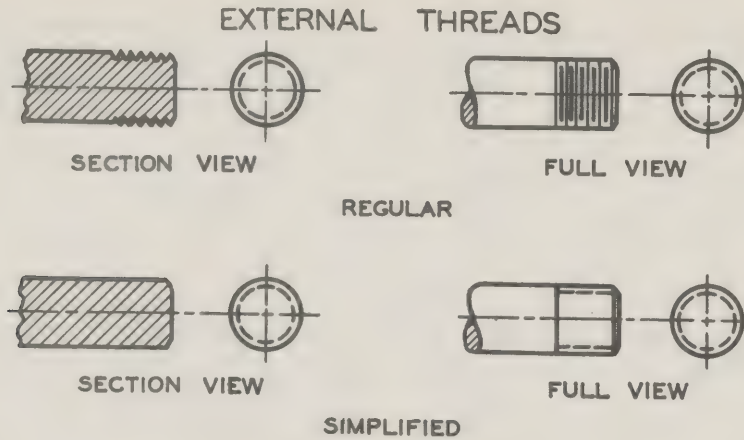


Fig. 78.

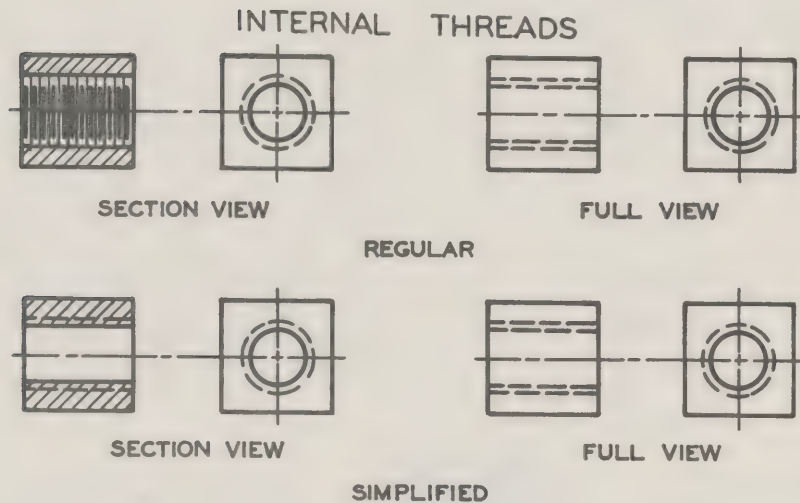


Fig. 79.

The drawings of many complicated parts are greatly simplified by the use of symbols. A good example of simplification is found in the details of thread drawings. Fig. 78 and figure 79 show some symbols indicating both regular and simplified methods of drawing threads. You are not expected to study these in detail.

Some of the related trades, such as the electrical, welding, sheet metal and woodworking trades have their special symbols and abbreviations.

For instance, in making an installation or a repair of a unit such as an electrically operated instrument or radio, it is often necessary to refer to a diagram of the electrical circuit. In these diagrams,

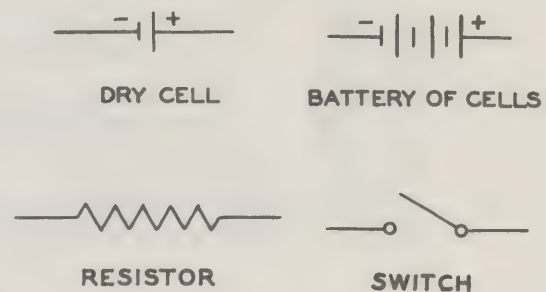


Fig. 80.

symbols represent the various parts used in the circuits. See fig. 80 for examples of these symbols.

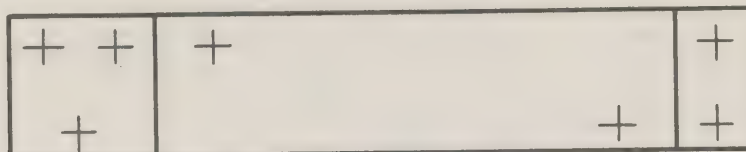


Fig. 81.

The aircraft sheet metal trade uses the symbol + for holes. Its purpose is to locate the *exact center* for drilling. Fig. 81 shows how these symbols might appear on a drawing.

The symbol X is used in aircraft assembly to tell that the bolt  is made of alloy steel.

The welding trade has numerous symbols and abbreviations, some of them quite complicated. Two of the very common symbols are // and xxxxxx. Either one can be used to indicate a welded joint. Fig. 82 shows how these symbols might be used.

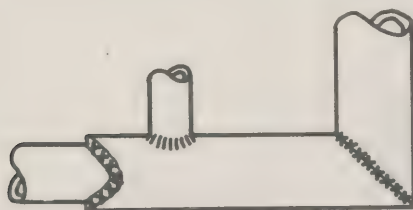


Fig. 82.

Abbreviations are very often used on all types of aircraft drawings. A few of the most common abbreviations are listed below.

Aluminum---Alum. or Al.	Cylinder----Cyl.
Aluminum Alloy---Al.-Alloy	Diagonal----Diag.
Assembly---Assem.	Drawing-----Dwg.
Bearing----Brg.	Extrusion---Extr.
Bill of Material-B/M	Fillet-----Fil.
Bracket----Brkt.	Flat Head---F.H.
Bushing----Bush.	Fuselage----Fus.
Casting----Cstg.	Gage-----Ga.
Center-----Ctr.	Grade-----Gr.
Center to Center---c-c	Heat Treat--H.T.

Complete lists of abbreviations and symbols are available for all types of drawings. A more detailed study of this phase of reading drawings is given in specialized and advanced trade work.



Many drawings are made as diagrams or schematic drawings. In these drawings color is extensively used to designate certain parts, materials, and in some cases, action of parts.

Fig. 83 shows how colors are used as symbols with the help of various symbolic shapes. This diagram is of a Hydraulic System Pipe Line for a certain type of airplane. Notice the use of colored stripes and combinations of colors.

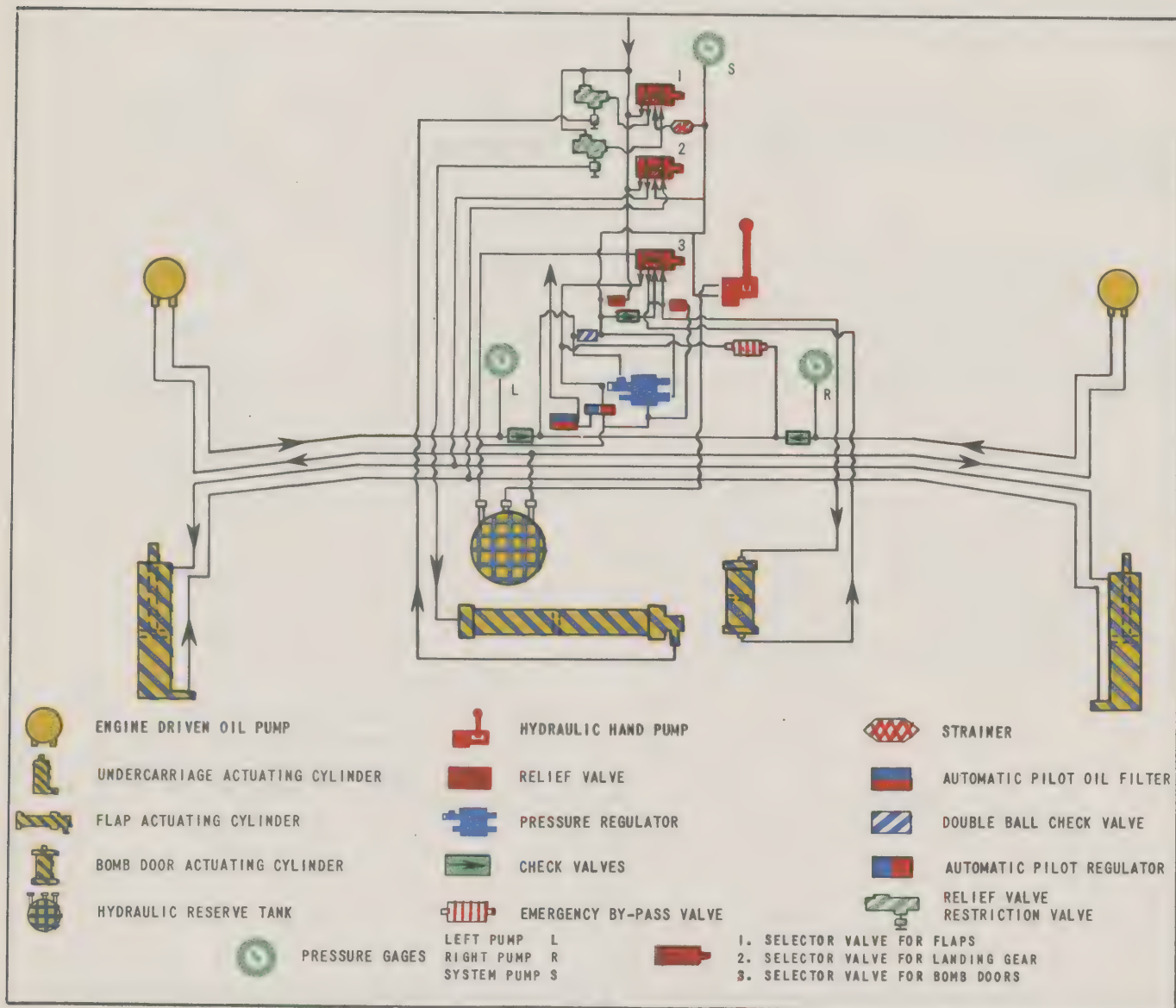


Fig. 83.

Questions

1. What is meant by symbols?
2. What is the value of symbols on drawings?
3. What are the proper symbols for the following:
 - a. Centerline.
 - b. Finished surface (two kinds).
 - c. Break line in wood.
 - d. Break line in a round solid object.
 - e. Break line in a round hollow object.
 - f. Break line in metal.
 - g. Center of a hole.
 - h. Angle.
 - i. Aluminum.
 - j. Steel.
 - k. Battery.
4. Explain the meaning of the term "finish" when applied to the manufacture of metal parts.
5. Show two symbols for indicating welds in drawings.
6. How are colors used as symbols in drawing?

		I	2 3/4 X 2 3/4 S.W. S.L.	.040 SHEET ALUMINUM 2500 OR EQUIV.	FED. QQ-A-561 TYPE I	47-A-2 COND. A			
R.H.	L.H.	NO	SIZE	DESCRIPTION	ARMY	NAVY		ZONE	
DASH NO.		REQ	MATERIAL			MATERIAL SPECIFICATION			
			LIMITS ON DIMENSIONS UNLESS OTHERWISE SPECIFIED ANGULAR $\pm 1/2^\circ$ FRACTIONAL $\pm 1/32$ DECIMAL $\pm .010$ ③ SMOOTH MACHINE FINISH ⑤ ROUGH FILE OR GRIND			APPROVED	NAVY		
						CHECKED	ARMY		
NAVY							ENG.	KINK, S.P.	3/6/41
ARMY							PRE.ENG		
FINISH			SCALE — FULL SIZE			CHECKED	MAT'L	WHITE, R.	3/4/41
							STRESS		
HEAT TREAT						CHECKED	ENG.	WEST, P.L.	3/2/41
							DRAFTSMAN	PARK, R.M.	3/1/41
CUP - CARGO COMP'T - LIGHT SWITCH						DWG. AREA		1.12	SQ. FT.
						10205409			

Fig. 85.

Fig. 85 is an enlarged drawing of the title block shown in fig. 84. The size of the block shown in fig. 85 is approximately the same as would appear on an actual drawing. The name of the company that made this drawing would appear in the large space directly under the space labeled "Draftsman." The title block has been completed with all the necessary information concerning the drawing of the part. The following illustrations explain each step of the procedure used in filling in this information.

R.H.	L.H.	NO	SIZE	DESCRIPTION	ARMY	NAVY		ZONE
DASH NO.		REQ	MATERIAL			MATERIAL SPECIFICATION		
			LIMITS ON DIMENSIONS UNLESS OTHERWISE SPECIFIED ANGULAR FRACTIONAL DECIMAL			APPROVED	NAVY	
						CHECKED	ARMY	
NAVY							ENG.	
ARMY							PRE.ENG	
FINISH			SCALE —			CHECKED	MAT'L	
							STRESS	
HEAT TREAT						CHECKED	ENG.	
							DRAFTSMAN	
						DWG. AREA		SQ. FT.

Fig. 86.

Fig. 86 shows the typical printed form of a title block with the spaces left blank and ready to be filled in by the draftsman or engineer.

With thousands of drawings being made, each company must have a method of locating drawings in a filing system. The most satisfactory method is to number each drawing. First let us put the drawing number in the proper space. See fig. 87.

R.H.	L.H.	NO.	SIZE	DESCRIPTION	ARMY	NAVY				ZONE
DASH NO.	REQ.		MATERIAL		MATERIAL SPECIFICATION					
			LIMITS ON DIMENSIONS UNLESS OTHERWISE SPECIFIED ANGULAR FRACTIONAL DECIMAL		APPROVED	NAVY				
						ARMY				
NAVY						ENG.				
ARMY						PRE.ENG				
FINISH					CHECKED	MAT'L				
						STRESS				
						ENG.				
HEAT TREAT			SCALE —		DRAFTSMAN					
					DWG. AREA		SQ. FT.			
					10205409					

Fig. 87.

In some factories, the number of the drawing is also the number of the part shown, and in that way it is easy to realize that the part and the number go together. Because the lower right-hand corner of the drawing sheet has the most wear, it is sometimes advisable to repeat the drawing number in the upper left-hand corner. This will enable the drawing to be identified in case the title block number is destroyed.

Directly above the drawing number is a small space labeled DWG. AREA - SQ. FT. The area of this particular drawing sheet is 1.12 square feet. See fig. 88.

Fig. 88.

R.H.	L.H.	NO.	SIZE	DESCRIPTION	ARMY	NAVY				ZONE
DASH NO.	REQ.		MATERIAL		MATERIAL SPECIFICATION					
			LIMITS ON DIMENSIONS UNLESS OTHERWISE SPECIFIED ANGULAR FRACTIONAL DECIMAL		APPROVED	NAVY				
						ARMY				
NAVY						ENG.				
ARMY						PRE.ENG				
FINISH					CHECKED	MAT'L				
						STRESS				
						ENG.				
HEAT TREAT			SCALE		DRAFTSMAN					
					DWG. AREA		1.12		SQ. FT.	
CUP - CARGO COMP'T - LIGHT SWITCH					10205409					

To help identify the drawing we must add to the title block the NAME OF THE PART. See fig. 88.

In aircraft work the name of the part is given first, followed by a description of the place in which the part belongs. In this case it is a cup for a cargo compartment light switch. The name is separated from its location either by a dash line or by placing the description of the location underneath the name.

The size of the drawing is not always the same as the size of the actual part. In the title block, **fig. 89**, you see a

space labeled **SCALE**. The drawing of the cup has been made the same size as the part itself, so we designate the scale as being **FULL SIZE**. A scale always shows the relationship of the size of the drawing to the actual size of the part itself. If the drawing of the part is half the size of the part itself, the scale would be noted as **HALF SIZE**, or $\frac{1}{2} = 1"$. The drawing is made one-half as large as the object, but the dimensions on the drawing are the same as the size of the object.

R.H.	L.H.	NO.	SIZE	DESCRIPTION	ARMY	NAVY			ZONE	
DASH NO.		REQ.	MATERIAL		MATERIAL SPECIFICATION					
			LIMITS ON DIMENSIONS UNLESS OTHERWISE SPECIFIED ANGULAR FRACTIONAL DECIMAL		APPROVED		NAVY			
					CHECKED		ARMY			
NAVY							ENG.	KINK, S.P.	3/6/4	
ARMY							PRE.ENG			
FINISH							MAT'L	WHITE, R.	3/4/4	
			SCALE — FULL SIZE		STRESS					
		ENG.			WEST, P.L.	3/2/4				
					DRAFTSMAN		PARK, R.M.	3/1/4		
HEAT TREAT										
CUP - CARGO COMP'T - LIGHT SWITCH					DWG. AREA 1.12 SQ. FT.					
					10205409					

Fig. 89.

On the right side of the block is a section divided into rather small spaces. The bottom space in this group is labeled **DRAFTSMAN**. Reading up, we find that the next three spaces are labeled **CHECKED** and the top four spaces are labeled **APPROVED**.

This section of the title block enables one to find out who made the drawing, who checked it, and who approved it.

The last column to the right gives us the dates the drawing was finished, checked and approved. See fig. 89.



Approximately in the center of the title block (just above **SCALE-FULL SIZE**) is information concerning dimension limits. See fig. 90. The note in this space tells us that unless it is specified elsewhere on the drawing, the angular limit is $\pm 1/2^\circ$; that is, the angle of any part may be constructed one-half a degree larger or smaller than specified, and still be acceptable.

Fractional dimensions as given on the drawing may vary on the finished product $\pm 1/32$.

Decimal dimensions as given on the drawing are allowed variation of $\pm .010$ " on the finished product and will be accepted.

Also included in this space is information regarding the symbol for two types of finishes. Number 3 designates a smooth machine finish; number 5 a rough file or grind finish.

		I	2 3/4 X 2 3/4 S.W.	.040 SHEET ALUMINUM 250 OR EQUIV.	FED. QQ-A-561 TYPE I	47-A-2 COND. A		
R.H.	L.H.	NO	SIZE	DESCRIPTION	ARMY	NAVY		ZONE
DASH NO.		REQ	MATERIAL		MATERIAL SPECIFICATION			
			LIMITS ON DIMENSIONS UNLESS OTHERWISE SPECIFIED ANGULAR $\pm 1/2^\circ$ FRACTIONAL $\pm 1/32$ DECIMAL $\pm .010$ ③ SMOOTH MACHINE FINISH ⑤ ROUGH FILE OR GRIND			CHECKED APPROVED NAVY ARMY ENG. KINK, S.P. 3/6/41 PRE.ENG MAT'L WHITE, R. 3/4/41 STRESS ENG. WEST, P.L. 3/2/41 DRAFTSMAN PARK, R.M. 3/1/41		
NAVY								
ARMY								
FINISH								
HEAT TREAT			SCALE — FULL SIZE					
CUP - CARGO COMP'T - LIGHT SWITCH					DWG. AREA 1.12 SQ. FT.			
					10205409			

Fig. 90.

The space at the center of the left-hand edge of the title block has not been filled in. This shows us that neither the Army nor the Navy has specified any type of finish for this part.

If the completed part is to have a special finish, such as a highly polished surface or a painted surface, or is to be heat treated, the required information is given in the spaces marked **FINISH** and **HEAT TREAT**. See fig. 90. Since no special finish is required, we will leave blank the spaces directly above the cup, so the triangular spaces above the label **HEAT TREAT** are also left blank. (Heat Treatment is a method of hardening metal) or otherwise improving it by means of heat.

Reading from left to right along the top of the block, we learn that this light switch cup is neither right-hand (R.H.) nor left-hand (L.H.). Some parts will fit only the left or right side of the plane and must be designated in the proper spaces. Only one switch cup is required for each plane. (See space labeled **NO. REQ.**)

The size of the material will be S.W. $2\frac{3}{4}$ " (stock width is to be $2\frac{3}{4}$ ") and S.L. $2\frac{3}{4}$ " (stock length is to be $2\frac{3}{4}$ ".) The material is to be .040" sheet aluminum (.040" thick.) The composition of the material is to be 2 SO or equivalent. (2 SO is code for a grade of soft aluminum).

The material specification is in code for the Army, FED.QQ-A-561, TYPE I, and for the Navy, 47-A-2, COND. A. These specifications would be known to persons familiar with the Army and Navy standards.

Study the various parts of the title block and familiarize yourself with them.

A	1/2 WAS 15/32		3/2/41	P.L.W.	S.P.K.			
LET.	CHANGE		DATE	BY	APP.			
	ACT. WT.					1	540179	DC-2
	CAL. WT.					NO.REQ.	NEXT ASSEM.	MODEL

Fig. 91.

On most prints you will find a second block similar to the title block but not so large. The purpose of this block is to note any changes made on the drawing, the weight of the part, and the number of these parts required for the next assembly.

We can see (fig. 91) that there was one change made; $1/32$ " was added to the dimension. The space labeled LET. (letter) has in it the letter A, which signifies that the dimension on the drawing labeled with an A was originally $15/32$ " long and that $1/32$ " was added, making the corrected dimension equal to $16/32$ " or $1/2$ ". See space labeled CHANGE.

A workman should *not* measure the size of the drawing and make his piece accordingly, because the dimensions in drawings are sometimes changed without redrawing the part.

The next space contains the date, followed by a space designating by whom the change was made. (S.P.K. approved the change.) The spaces in the lower left corner show that no weight for the part is given. The lower right section of the block shows that one part is required for the NEXT ASSEMBLY 540179 on MODEL DC-2.

The answers to the nineteen questions listed on page 47 will be found on the drawing in fig. 92. Read carefully the information given both in the title block and on the drawing itself.

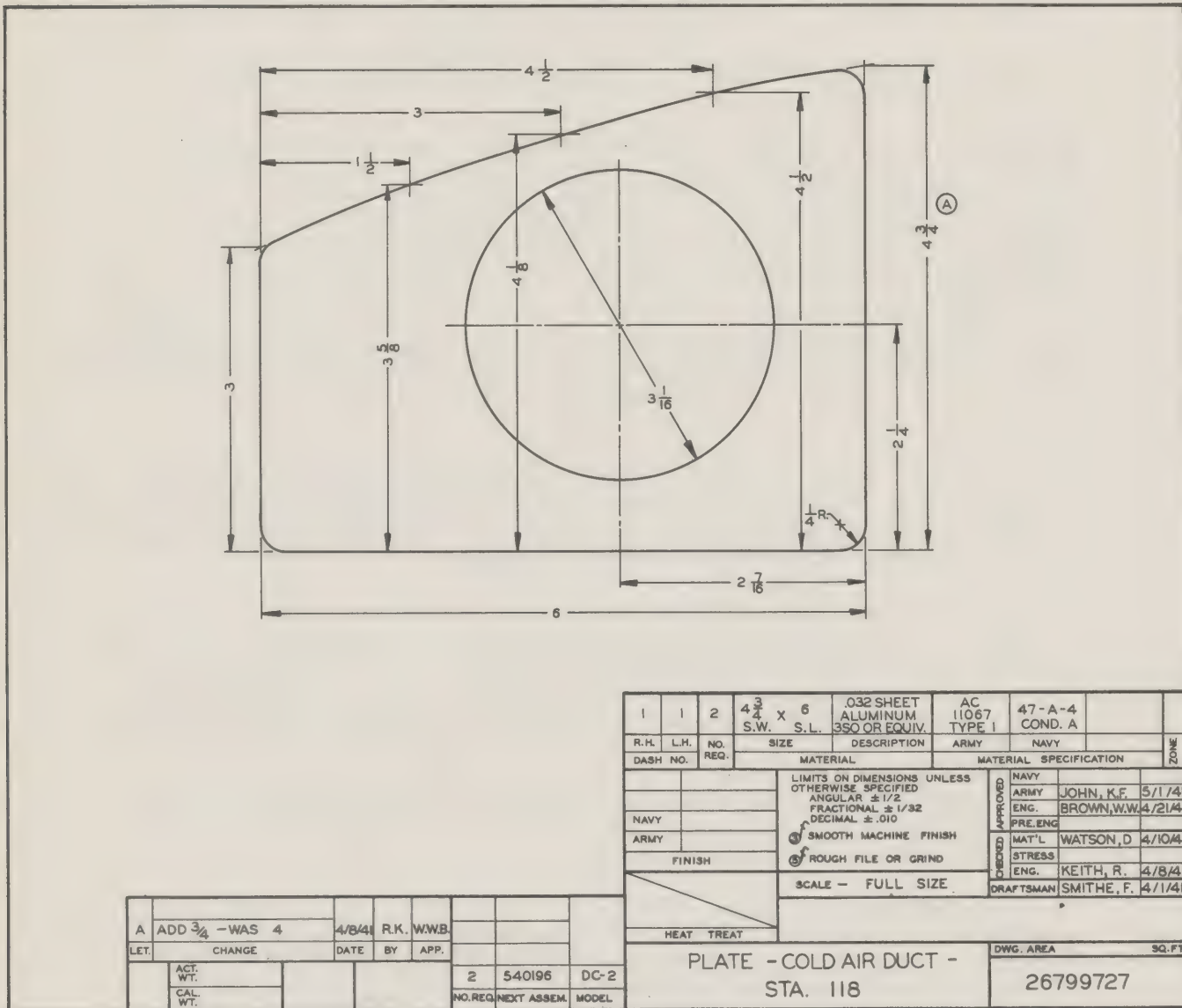


Fig. 92.



Questions

1. What is the name of the part shown in the drawing?
2. Where is this part used?
3. What is the drawing number?
4. How many parts are required?
5. What change has been made on the print?
6. What was the date of the last change?
7. Describe the shape of the piece.
8. What scale was used in making the drawing?
9. Of what material is the part made?
10. What decimal limits are allowable?
11. What fractional limits are allowable?
12. What Army material specification is given?
13. What heat treatment is to be given?
14. What Navy material specification is given?
15. Who was the draftsman?
16. What is the number of the next assembly?
17. Who approved the drawing?
18. Who checked this drawing?
19. Who approved the change?

Section 7. Sectional Drawings

Sectional Drawings make it possible to look inside a part.

Fig. 93 is a drawing of an elbow fitting used in the construction of an airplane. This drawing shows the shape of the part but very little about its construction. If we wished to know more in detail just how this elbow is constructed, we would need a drawing similar to fig. 94.

Fig. 94 shows the part with half of it cut away. The cutting plane line shown in the top view determines the exact place where the section is to be made. The arrows show in which direction you should look at the exposed section.

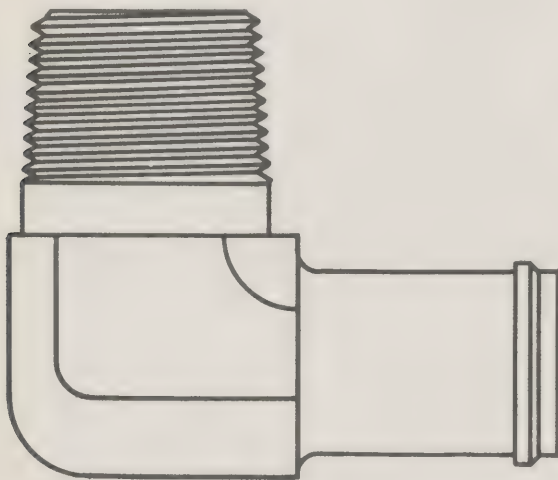
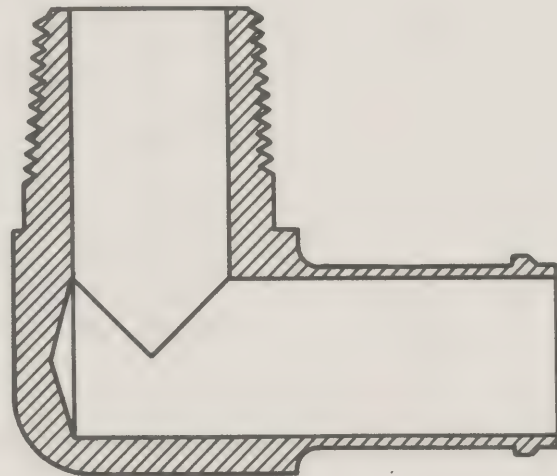
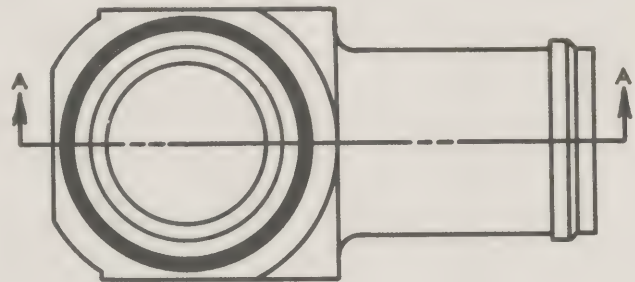


Fig. 93.

In the Section A-A (lower view in fig. 94) you will notice that the shape and size of the opening running through the elbow is visible.

The Section A-A also shows clearly the thickness of the metal at various parts of the elbow. Wherever metal has been cut by the cutting plane line, we indicate the metal by the use of light section lines drawn close together. Wherever there is a hole or no material, the lines are omitted.



SECTION A-A

Fig. 94.

A Sectional Drawing shows a part as if it were cut in two. Actually, the draftsman *imagines* what the cross section would look like. But you will find the cross section easier to read if you see clearly what happens in his imagination.

Fig. 95 is a sketch of the metal part that must be sectioned.

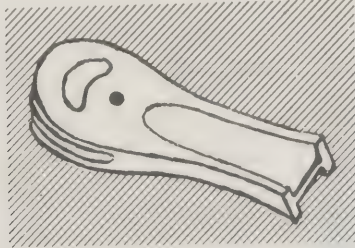


Fig. 95.

Imagine that the metal part is cut in two with a hack saw, as in fig. 96.

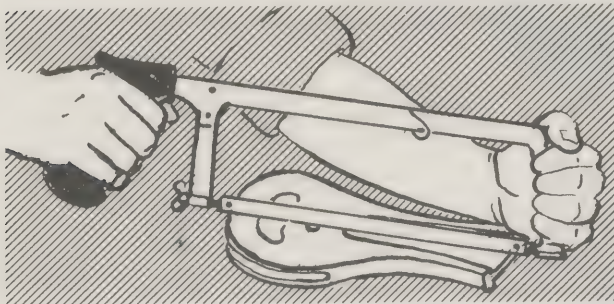


Fig. 96.

Fig. 97 shows the part after it has been sawed with the nearest half removed. The sectional view will show the remaining part as we look at the cut surface.

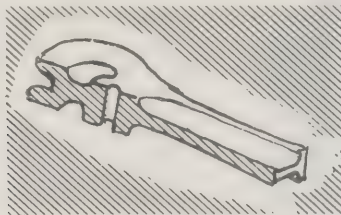


Fig. 97.

Wherever material is "cut," the cutting plane line must be located as shown by the line A-A in the full view of fig. 98. Wherever there is space such as the inside of a hole or hollowed part, there will be no section lines. See figs. 97 and 98. In Sectional Drawings of assembled parts where the cutting plane line passes through a bolt or rivet, it is common practice to omit the section lines in the space occupied by the bolt or rivet.

Fig. 98 shows this arm exactly as it would be on a mechanical drawing or finished print. Notice how the sectional view is directly opposite the full view. This position helps you to follow across from full view to section, and to understand where the blank spaces on the sectional view fit into the full view.

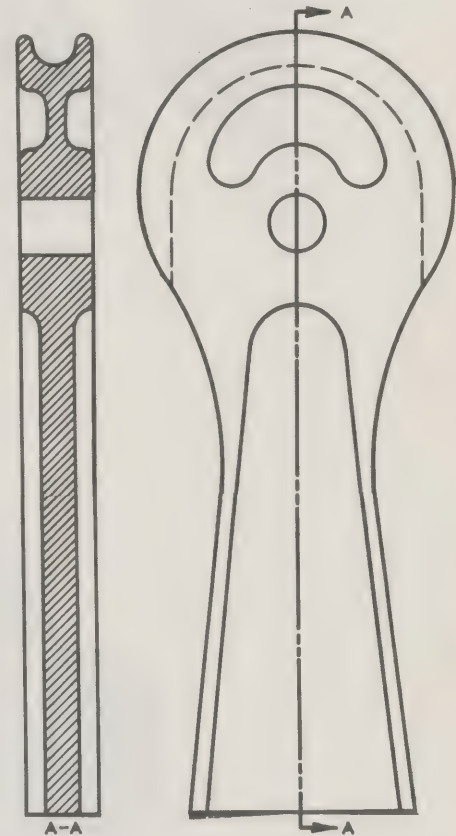


Fig. 98.

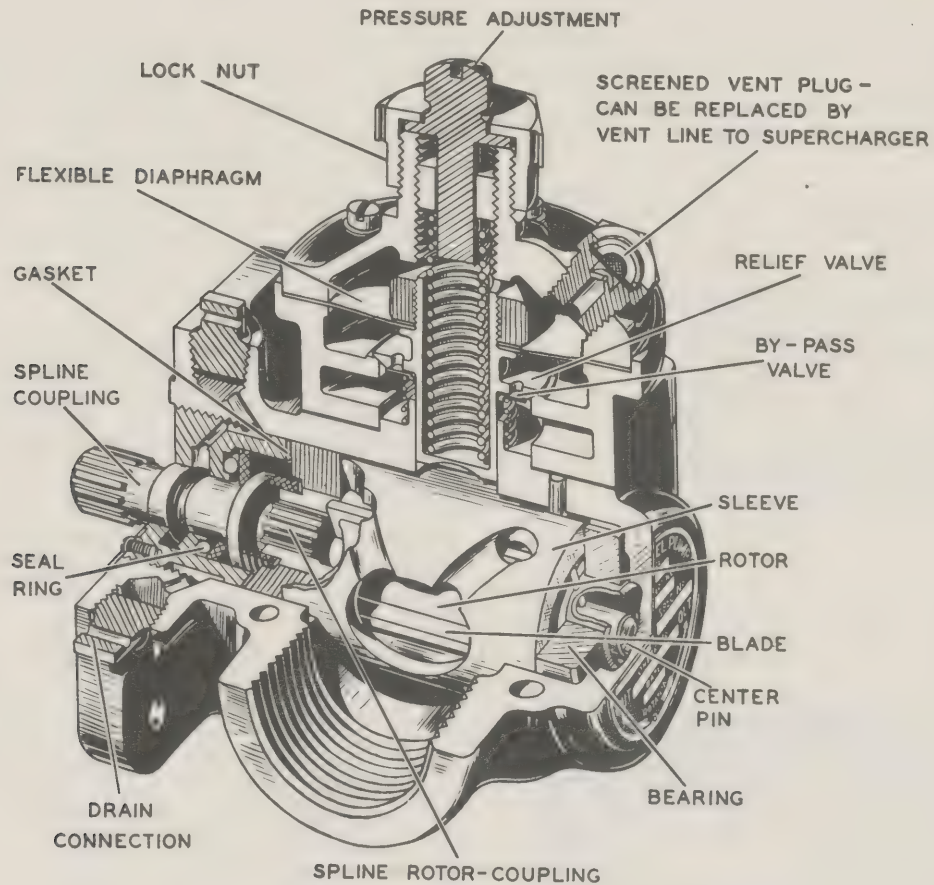


Fig. 99.



Fig. 100.

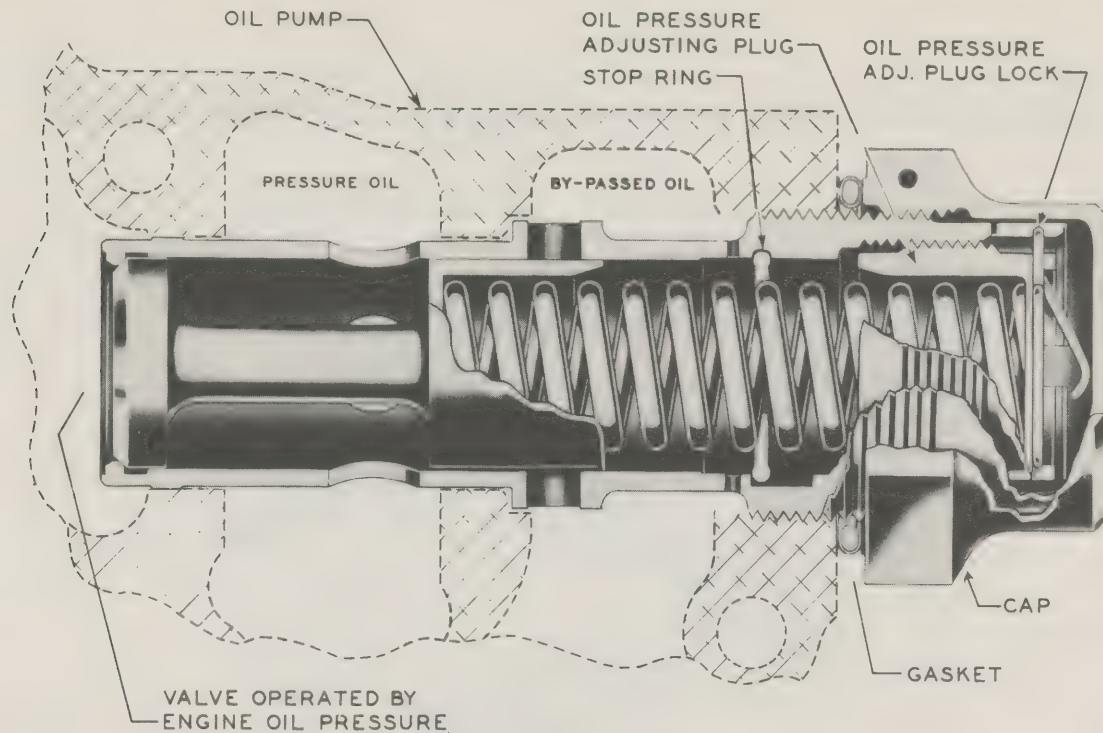


Fig. 101.

Fig. 99 is an artist's sketch of a pump. One quarter of the pump has been removed. This type of cutaway drawing is very valuable because it shows the inside parts of the pump, the relationship of one part to another in its assembly, and also gives a good idea of the general shape of the entire part.

Fig. 100 is a photograph and typical view of the same type pump. Notice how much more information is available from fig. 99.

Sometimes you may see an artist's Sectional Drawing similar to fig. 101. This will show the parts, their relationship to one another and their position in the whole valve. This type of sketch is becoming more popular with mechanics because it shows clearly both the shape of the parts of the valve and their positions *inside* the valve.

You will also notice the adjacent parts shown by the dash lines. The shaded area indicates sectioning of the adjacent parts.

Questions

1. What is the purpose of Sectional Drawings?
2. Why is it desirable to have symbols for various materials?
3. What is the advantage of an artist's drawing in sectioning?
4. What determines the number of sections that the draftsman will use in one drawing?
5. What is meant by cutting plane line?

Section 8. Exploded, Detail and Assembly Drawings



Fig. 102.

Assembling thousands of small parts into a whole unit that will fly is a tremendous and fascinating task. Some of the small planes are comparatively simple in their structure, but the large ones are complex and difficult to construct. To build a plane of any size, workers need drawings showing the details necessary for making small parts, drawings showing how the parts are put together, and drawings showing the completed structure of each assembly. You are already familiar with some kinds of Detail Drawings, as Three View, Two View, or One View Drawings. You know, therefore, a Detail Drawing is any mechanical drawing which shows the dimensions and other information needed to manufacture a single part.

The workers in fig. 102 are probably using several kinds of drawings that show them how to put together the wing of a giant bomber. Several major assemblies make up the bomber. A major assembly is composed of sub-assemblies and single parts. Some of these parts present few

problems in manufacture, while others are so complicated and intricate in detail as to challenge the imagination and skill of the most expert craftsmen.

Fig. 103 shows an Exploded Drawing of the same bomber. It gives you a general understanding of the way the major assemblies of the bomber go together. The major assemblies are the various parts which are broken away from each other as large units. For example, the power plant *X* is shown as a complete unit, even though it actually is composed of many small parts. Also, the main part of the body or fuselage, *B*, is shown as one piece when in reality it consists of many complicated units.

Fig. 104 shows another exploded view of the same bomber, but with each large unit broken down into smaller assembly parts. Notice that the power plant *X* and the fuselage *B* have been pulled apart into their smaller elements. For this reason, the title of this drawing is "Sub-assembly Breakdown."

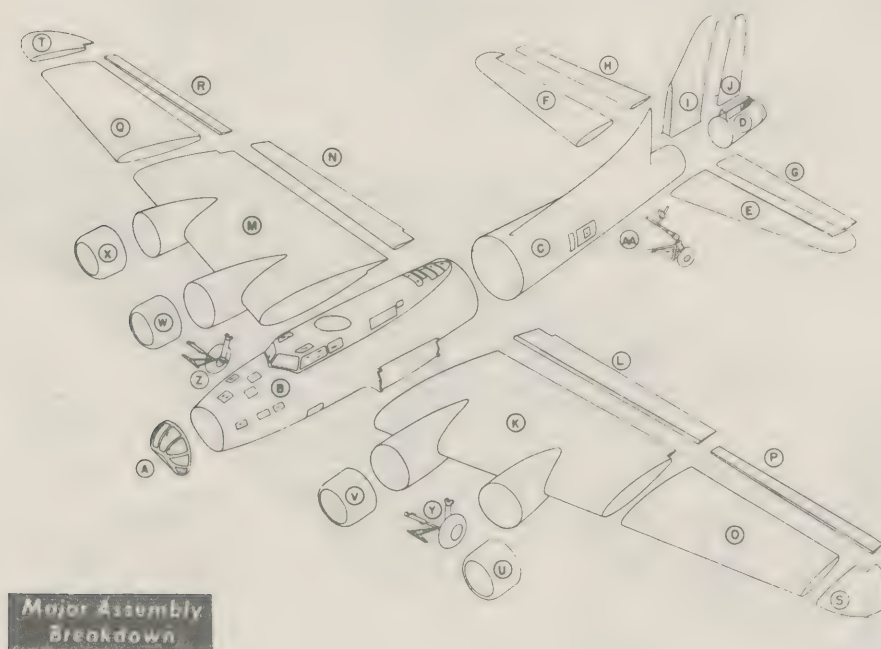


Fig. 103.

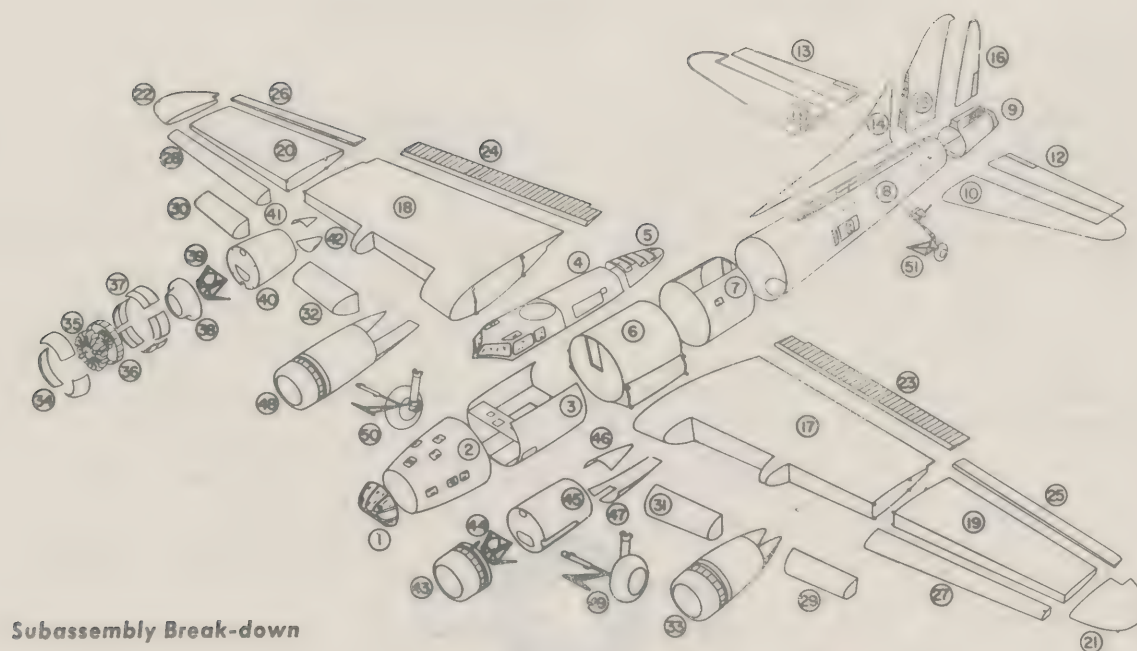


Fig. 104.

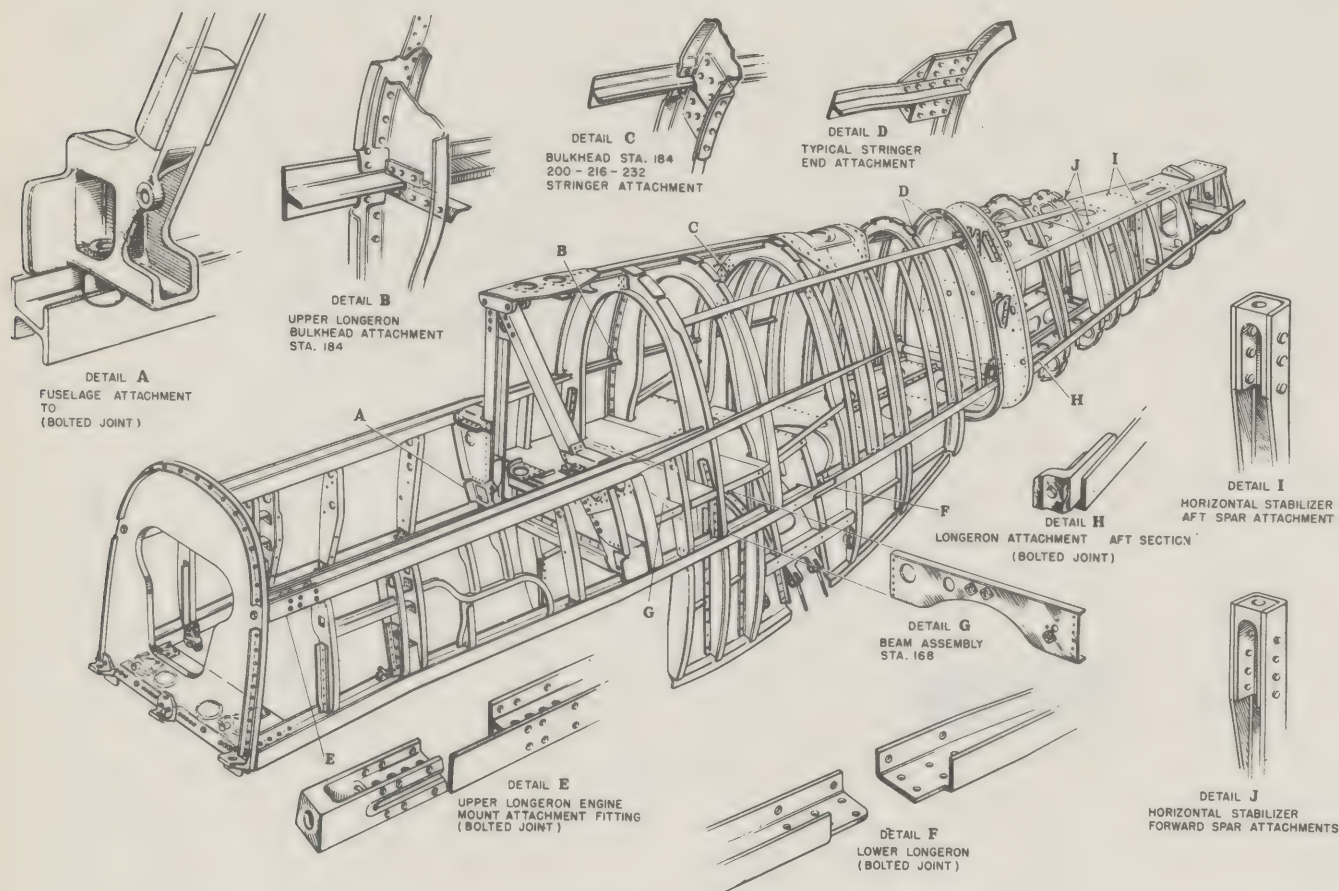


Fig. 105. Fuselage Structural Diagram.

Structural diagrams also help workers to find out how planes are put together. Fig. 105 is a structural diagram which shows the construction of the fuselage. In it, we can see clearly how the various small parts are assembled as a unit. Where the construction is not clear, a portion has been drawn on a larger scale at one side of the main drawing. It is not a Detail Drawing because it does not give the information needed for manufacturing the

part. The above drawing, however, shows the detailed construction of a large assembly.

This particular drawing is useful because it shows in a general view the location of parts in relation to one another; and at the same time it illustrates, at larger size, joints and fastenings which might be difficult to visualize in the drawing of the completely assembled unit itself.



Before the major units of a plane are ready to be put together, the workers must use Detail Drawings, and Assembly Drawings guide the manufacture of each small part. Assembly Drawings show the appearance of two or more parts *after* they have been put together.

Let us look at some Detail Drawings typical of those required to manufacture various parts of the airplane. Fig. 106 is a Detail Drawing of a gusset plate. You will notice that this part is fully explained by the use of only *one* view. All of the necessary information for manufacture is presented by the drawing, its dimensions, and notes.

The right-side view, if shown, would be a straight, vertical line, or very thin

edge view. It is apparent that this second view is not necessary as the piece is flat and the thickness is shown in a note under the drawing.

According to the note at the bottom of the drawing the gusset plate is to be made from a sheet of aluminum alloy, .040" thick. The type of alloy is indicated by 24ST. The size of this metal sheet is $2\frac{1}{4}$ " wide Stock Width ($2\frac{1}{4}$ " SW), and $3\frac{1}{2}$ " Stock Length ($3\frac{1}{2}$ " SL).

The note at the top of the drawing tells us that the gusset plate is to be finished with two coats of zinc chromate primer, AC Specification No. 14080. There are to be three holes located according to the dimensions given. These holes are to be made with a #40 Drill, the diameter of the drill to be .098".

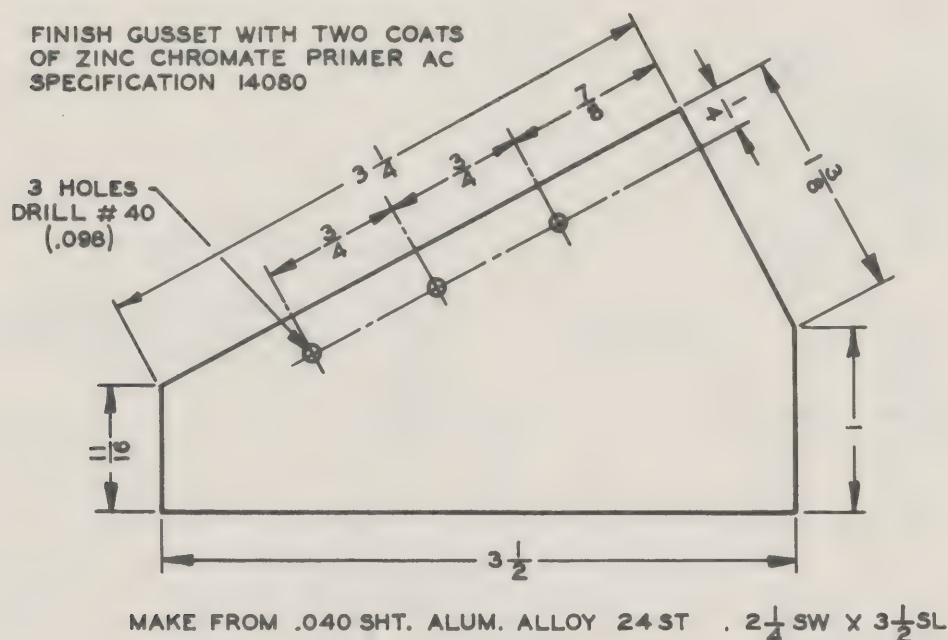


Fig. 106.

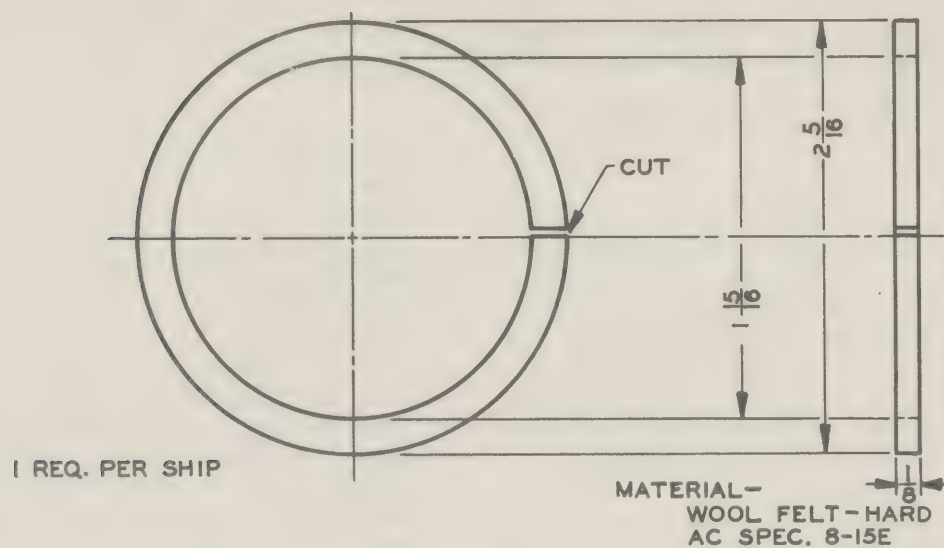


Fig. 107.

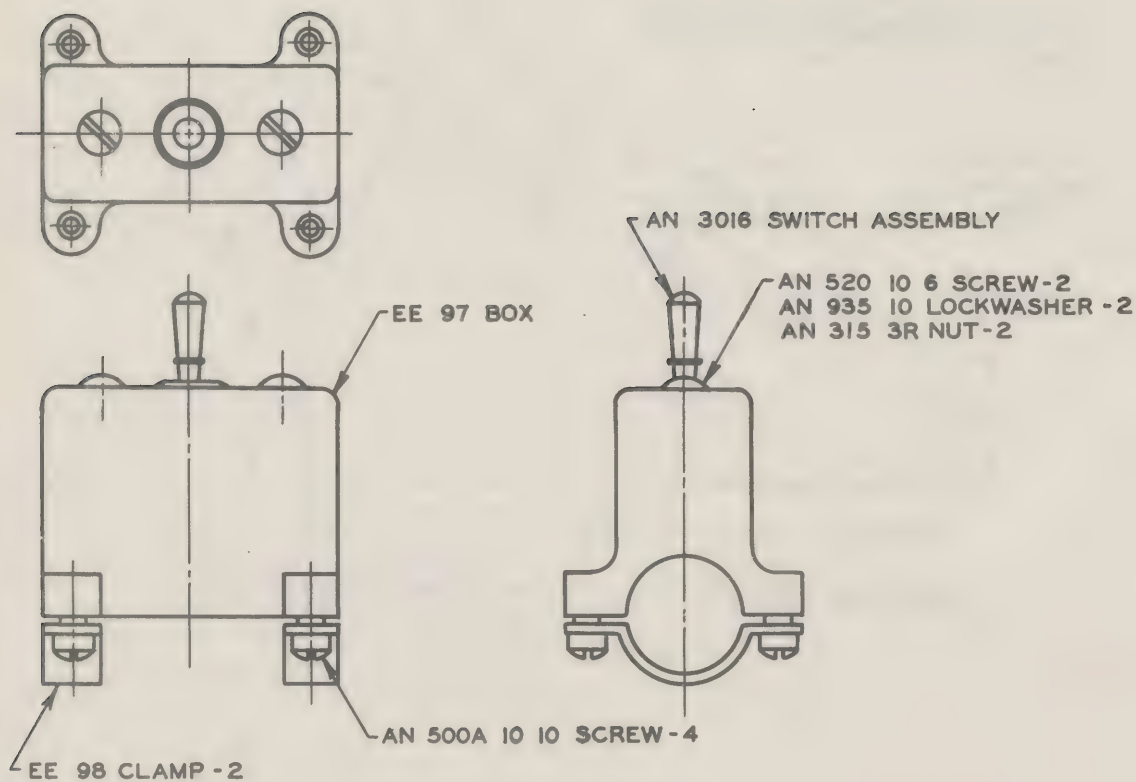


Fig. 108.

Some parts could be made and assembled using only a One View Drawing; but if some feature of the drawing might be misunderstood, other views might be added. A felt seal *could* be manufactured from a One View Drawing, but the Two View Drawing in Fig. 107 is used to present the desired information in clearer form.

This felt seal shown in fig. 107 is used for an elevator bearing on a plane. The view on the left of the drawing shows the general shape of the seal and the place where the seal is to be cut. The dimension to the right of this view tells us that the outside diameter of the ring is 2-5/16" and the inside diameter, or hole, is 1-15/16". The view on the right of the drawing gives us 1/8" as the thickness of the felt. The note indicates that the material is to be wool felt, hard, AC Specification No. 8-15E, and that one seal is required for each ship.

When a more complicated part is to be detailed, a Three View Drawing is usually needed. In this book, you have seen a number of such Detail Drawings* which guide the manufacture of certain small airplane parts.

An Assembly Drawing, on the other hand, shows a unit or assembly of two or more parts which have already been put together. Unlike a Detail Drawing, an Assembly Drawing usually does not give enough information so that a workman could use it as a guide in making any of the parts. It also differs from an Exploded Drawing (see fig. 104.), for an Assembly Drawing shows the completed construction rather than the

separated parts. For a typical Assembly Drawing, see the illustration of a handle switch assembly in fig. 108. Notes indicate the names and part numbers of the various parts of the switch.

It is also true, however, that Assembly Drawings are sometimes adapted to special uses. If the completed construction of an assembly is very simple, a worker can see from the Assembly Drawing how the parts go together. In this case, the Assembly Drawing is used in the same way as an exploded drawing or a structural diagram to show how parts are put together. At times when the assembly is not complicated, details about dimensions and other information for manufacture are included in the Assembly Drawing. In such a situation, the drawing is called a Detailed Assembly Drawing and also as an Assembly Drawing.

As an example of how these and other aircraft drawings are used in manufacture, repair and assembly, let us consider a small airplane instrument, the D-9 Manifold Pressure Gage. Fig. 109 shows the front and side views of this gage. The photograph of the side view is slightly reduced in size. If we wanted to install or disassemble, clean, adjust and reassemble the gage, we would need much more information than the photographs give us. We should know some of the main dimensions of the instrument, the order in which the parts are put together, the spacing, size and number of holes necessary to mount the instrument in the plane, and the way in which the various connections to the plane should be made.



Fig. 109.
D-9 Manifold Pressure Gage.

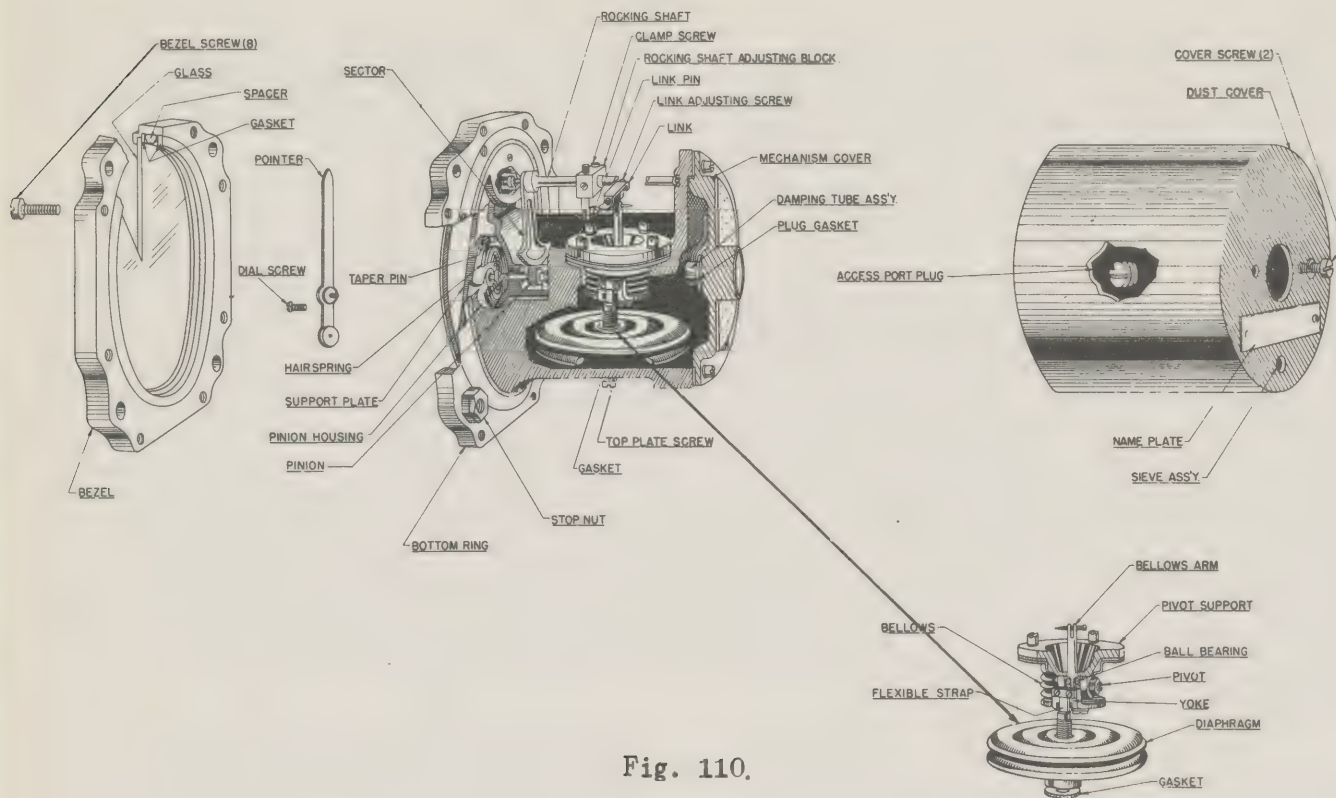


Fig. 110.

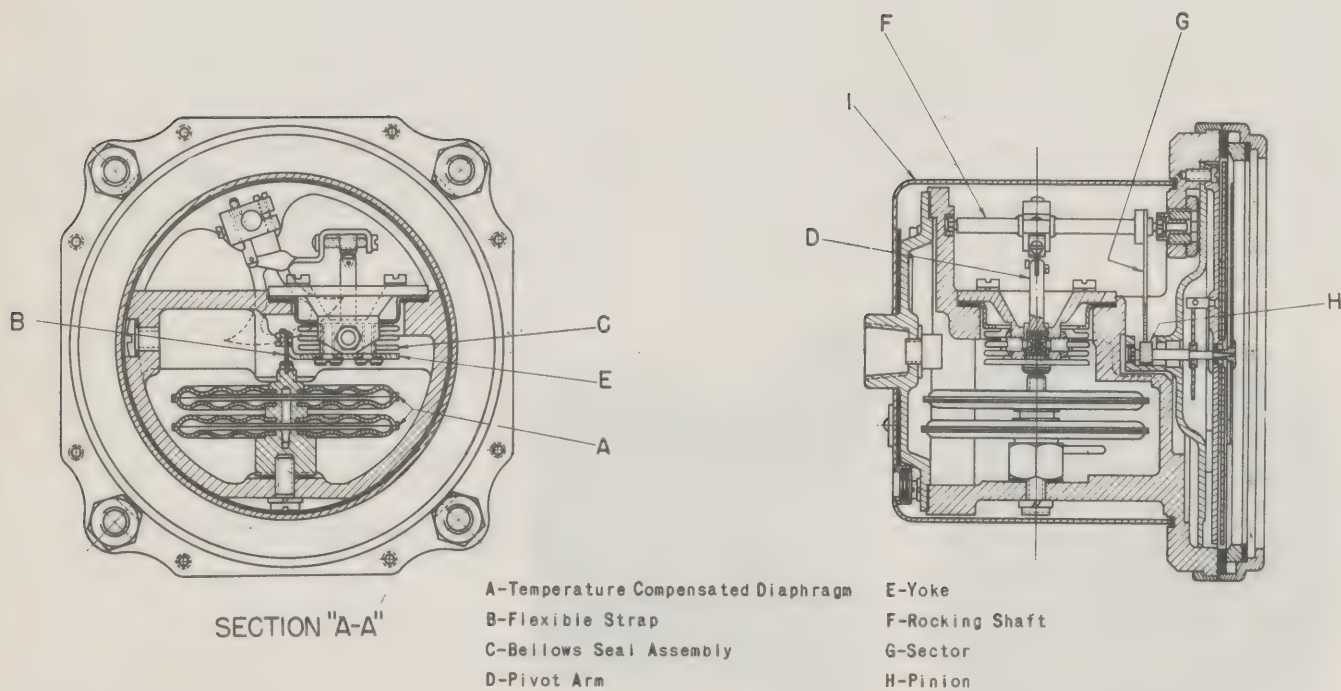


Fig. 111.

At first a number of Detail Drawings are needed to manufacture the parts of the gage. Other drawings, however, are needed for assembling and repairing the parts.

Fig. 110 is an Assembly Drawing of the gage showing the relationship of all parts in their assembled positions. For ease in reading, the main parts are lettered and explained in the list at the bottom of the drawing. Notice that this Assembly Drawing is also a Sectional Drawing.

The next illustration, fig. 111, is a type of Exploded Drawing. Here some parts are pulled away from each other, but they are still in their approximate positions, one to another. Two other features are added to this Exploded Drawing: first, some of the parts are cut away to show the inner construction; second, one of the parts, the diaphragm mechanism, has been repeated in the lower right-hand part of the drawing. Both of these features add to the usefulness and clearness of the drawing.

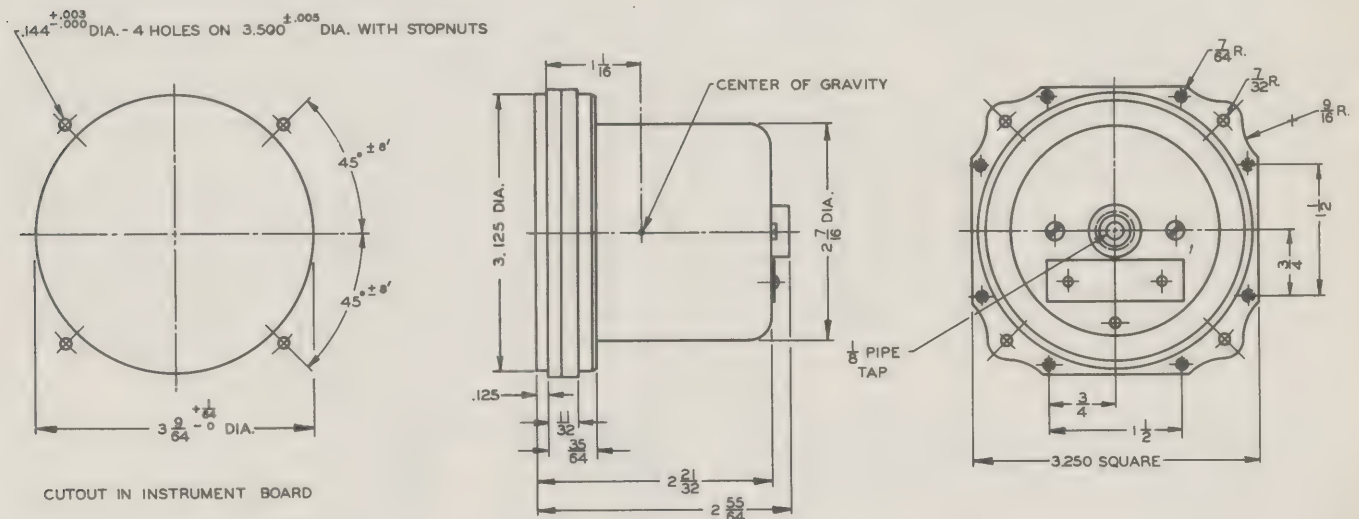


Fig. 112.

Fig. 112 is called an Installation Drawing or Dimensional Drawing. In order to install the gage on the instrument board of the airplane, we must have the information given on this drawing. For instance, we should know the dimensions of the part as a whole unit. We must also know the size and location of the holes used for fastening the device to the board, and

details about connecting the instrument to the manifold system.

In this chapter, we have seen a number of different kinds of aircraft drawings, and have discovered the main purpose of each. We must also realize that many variations of these basic types are used in aircraft work.

Questions

- | | |
|--|--|
| 1. What is a Detail Drawing? | Assembly Drawing? |
| 2. What is an Assembly Drawing? | 5. Why do we have One View Drawings? |
| 3. What determines the number of views of a Detail Drawing? | 6. What is the value of an Exploded Drawing? |
| 4. What is the importance of an accompanying sketch along with the | 7. What is the purpose of an Installation Drawing? |

Section 9. Care and Use of Prints

It is customary to duplicate a drawing, in order that more than one person may make use of its information at one time. It is also important to have duplicates of drawings to replace those accidentally destroyed, worn, or lost. Copies of drawings must also be kept on file as a record of what has been done.

The original drawing is usually made on transparent paper or cloth, and from this master copy, duplicates or prints are made.

These prints may be one of several kinds. Sometimes "Blue Prints" are used. Blue Print copies have a blue background and the lines of the drawing appear white on this background.

There are several processes of duplication where the background of the duplicate or print remains white and the lines are either black, sepia, or dark blue in color.

Prints are valuable. A print well cared for will last a long time. The care and use you give a print will immediately show how much you know about the correct use of a print and will tend to show what kind of a worker you are.

Each company has its own print library where all of the prints are filed, often in a "dark room" to prevent their being spoiled by contact with light rays. A master copy of each print is also kept. These prints can be removed and retraced and more prints made from the master copy in the event that all other available prints are lost or destroyed.

You must take into consideration that prints are necessary in field service. Remember that if your job should take you to an area which is not easily reached, you would have to make the prints you have on hand last for a long time. Therefore, you must not think of getting new prints whenever an old one gets dirty or is

slightly torn. You must learn how to keep all prints in good condition.

When you receive a print from the plant's print library or your foreman, it will probably be folded to the correct size for filing. Usually the number of the drawing is printed in the corner so that it is unnecessary to unfold it to determine just what it refers to. See fig. 113.

These folds should be observed and when opened should never be bent back on themselves. Print paper is brittle because of its exposure to strong light when printed, and if the print is folded any way but the original way, the print will soon separate in the folds.

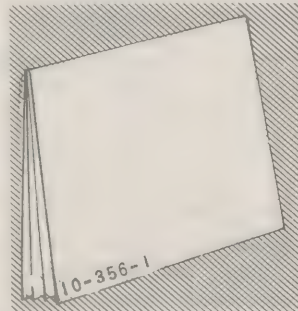


Fig. 113.

Four things are mainly responsible for damaging prints:

1. **Dirt:** Grime from your hands, or grease, mud or dust may obscure the drawing.
2. **Moisture:** Perspiration from your hands may spoil a print; also water, or solvents such as gasoline, Prestone or some other solution used on the job may damage the print.
3. **Tearing:** Prints should be handled carefully in a strong wind outdoors to prevent tearing. Also, careless handling and tools lying on the working surface may result in torn prints.
4. **Light:** Direct rays of light or the light in a building may destroy the print after a period of time.

These are the physical things that will damage a print: Prints are spoiled unconsciously by changing figures or inserting notes. If you should find a wrong dimension, do not change it or do not make any note on the print whatsoever. Report the error to the supervisor who will refer the print to the Engineering Department or the Drafting Department. **REMEMBER, only authorized engineers are permitted to make any changes on a print.**

Let us take a typical situation from start to finish in handling a print. We will assume that the print is a large one.

Wipe the grease or dirt from your hands before you get the print from the foreman or from the print library. You then take the print to the nearly completed plane on which you have been working. Benches here are full of tools. Workmen have been installing the hydraulic brake lines, and the floor is spotted with hydraulic fluid. The only place large enough and clean enough for the print is the wing of the airplane. See fig. 114.

You size up the situation and then wipe the wing of the plane to be sure that it is free of dirt and grease. You unfold the print, being careful to observe the way it has been folded, and lay it carefully on the wing. Here it will be clean, and in a position to be easily read.

When you have the necessary information from the print, carefully fold it in its original folds and place it in a drawer or

clean out-of-the-way place. If there is a designated place for prints to be kept near your job, do not hesitate to return it even though it may mean a little time and effort. If you will not need the print for some time, return it to the foreman or the print library.

If you return a clean, untorn, and neatly folded print after you have finished with it, you have passed one of the first steps in becoming a good, careful worker.

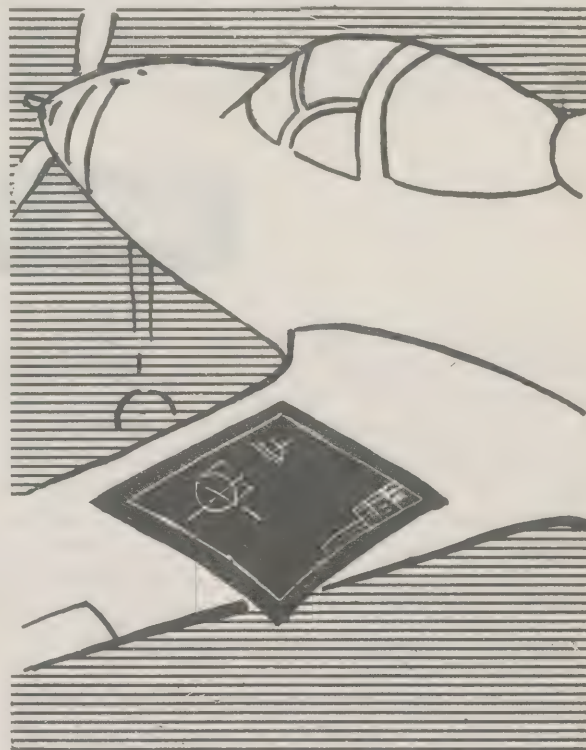


Fig. 114.

Questions

1. Name four ways in which the usefulness of prints is destroyed.
2. Why will print paper crack when folded in the wrong folds?
3. Why does the plant keep a master copy of each print?
4. What procedure would you follow to avoid damaging a large print you were going to use?
5. Why are prints often stored in a dark room?
6. What are the different types of prints?

Section 10. Pictorial Sketching

In the previous sections you have seen how mechanical drawings are made. You have observed that a mechanical drawing may be one view, two views, or three views, each view being distinguished by the observation point of a person who is looking directly

at one of the three surfaces -- top, front or side. A picture drawing, on the other hand, shows the appearance of an object from an angle, so that you see several surfaces from one viewpoint at the same time.

SEEING THE PICTURE

If you are to understand the shape of an object by seeing the views, when more than one view is given in the drawing, you must be able to *combine* the information from the views into *one* picture of the object. The following descriptions show you how the three views can be mentally assembled into picture drawings. The purpose is to describe paths for your thoughts so that you will be able to imagine quickly the picture of an object represented in a Three View Drawing.

Fig. 115 is a Three View Drawing of a wedge.

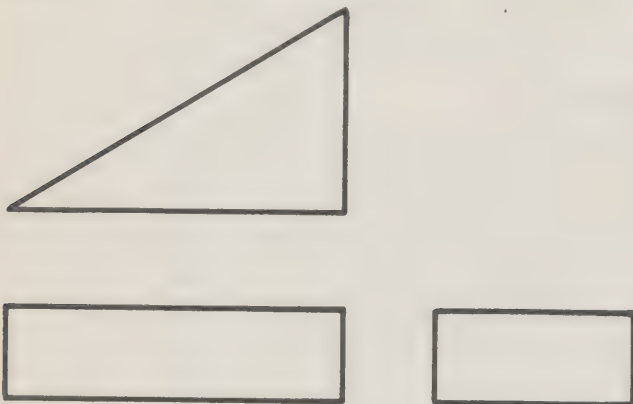


Fig. 115.

To combine these three views into a picture drawing of the wedge, we can follow the steps indicated in fig. 116.

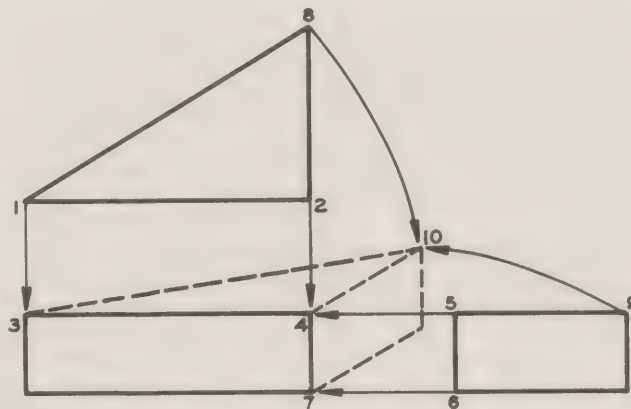


Fig. 116.

Move the top view down so that line 1-2 meets 3-4. Move the side view to the left so that line 5-6 will meet 4-7.

Pull points 8 and 9 together at point 10 by swinging the top and side part in the new positions to complete the picture.

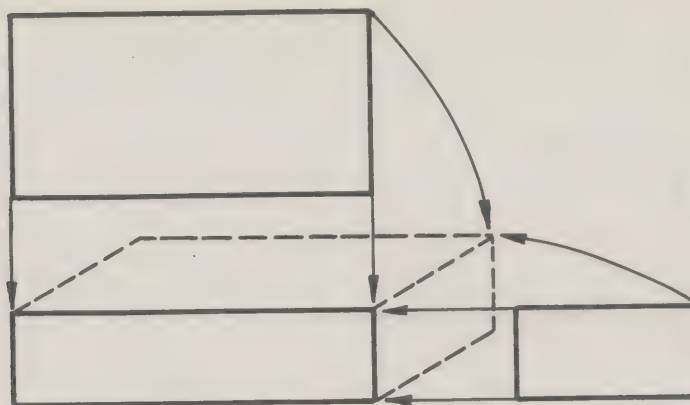
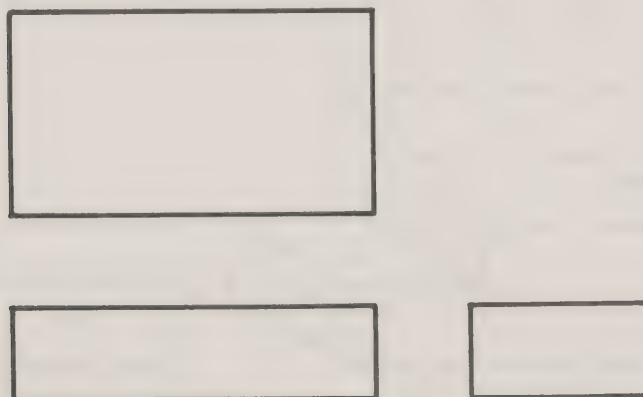


Fig. 117.

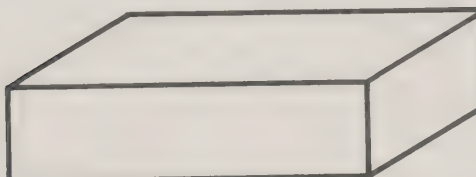
Similarly, in the Three View Drawing of a block shown by the solid lines in fig. 117, we can imagine the top view moving to the block in our mental picture.

The arrows shown near the right-side view suggest the movement of the right-side view to complete the picture of the object.



THREE VIEW DRAWING OF A BLOCK

Fig. 118.



PICTURE DRAWING OF THE BLOCK

Fig. 119.

If you can look at the three view of the block shown in fig. 118 and tell that the views represent an object which looks like fig. 119, you are reading the shape of the object.

If the surfaces are irregular, the process of changing the views into a picture is slightly different. See fig. 120.

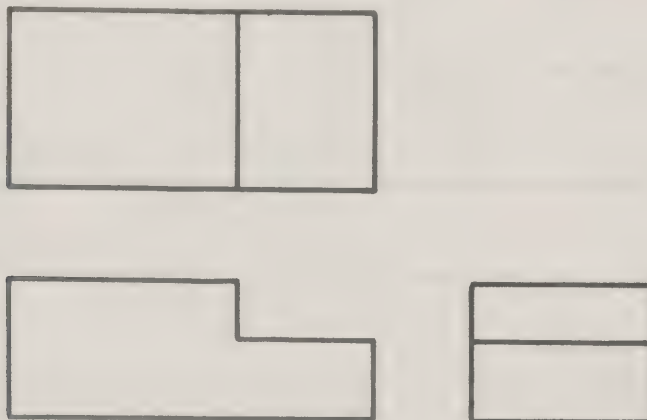


Fig. 120.

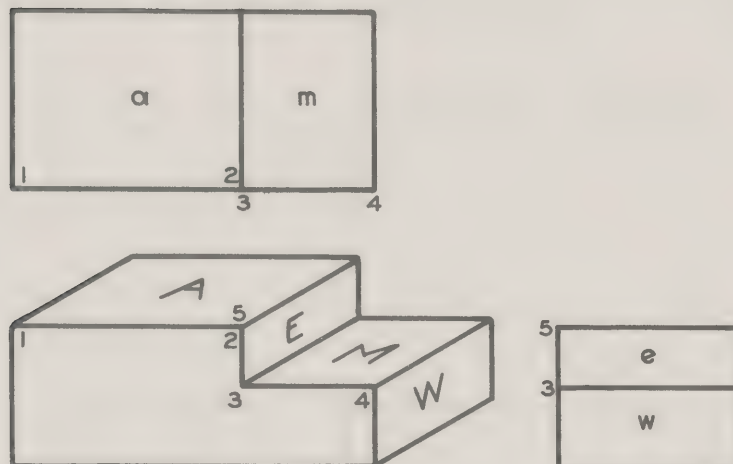


Fig. 121.

In order to imagine the top view in its position in the picture drawing, you can see from fig. 121 how surface *a* is put on to the front view at points 1 and 2 and becomes surface *A*. In order to place surface *m* in the picture sketch, it must be fastened to the corresponding line 3-4 of the front view. Surface *M* thus is lower than surface *A*. It is plain to see how surface *w* moves into its position *W*, and surface *e* moves back until the line 3-5 fits the corresponding line of the front view 2-3, thus fixing the surface at *E*.

When the front surface is irregular, part of the front view must be pushed back to fit the corresponding part of the top view. For example, see the part in fig. 122.

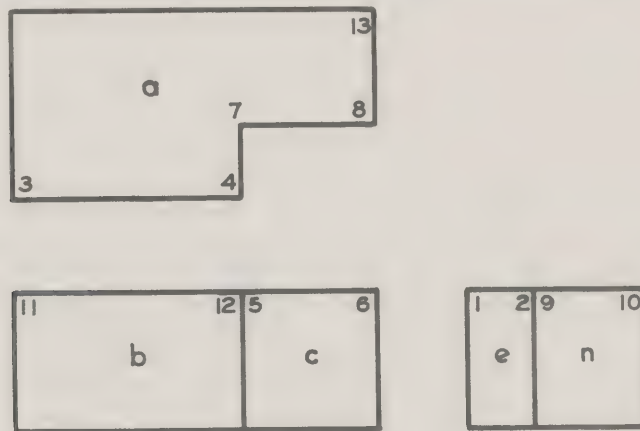


Fig. 122.

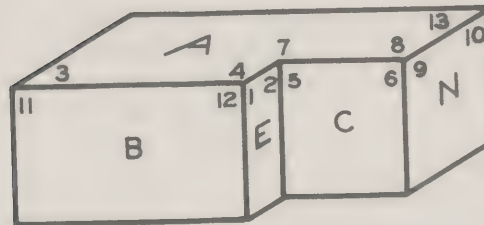


Fig. 123.

Surface **b** in fig. 122 is shown as surface **B** in fig. 123. Points **3** and **4** of the front view, and the top view **a** takes position **A** in the picture.

Surface **n** is placed in the picture drawing so that lines **9-10** joins line **8-13** of surface **A**.

Surface **e** is moved to take its place in the picture so that line **1-2** joins the corresponding line of the top view.

If a method of making a picture drawing from the information given in a Three View Drawing is clear to you, you will find that you readily imagine the real appearance of the object shown in any Three View Drawing. This ability to picture an object quickly and accurately is valuable in reading mechanical drawings.



MAKING A PICTURE DRAWING

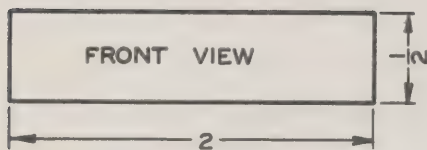


Fig. 124.

In addition to imagining the picture, you will find it useful to know how sketches are actually drawn. If you and a fellow worker are discussing a Detail Drawing of three views, you can make your point clear by sketching a picture which the Detail Drawing represents.

Let us suppose that you want to make a picture sketch of a block 2" long, 1" wide, and $\frac{1}{2}$ " in height or thickness. The procedure is as follows:

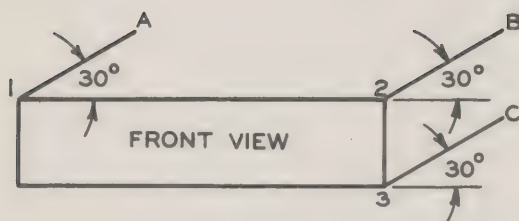
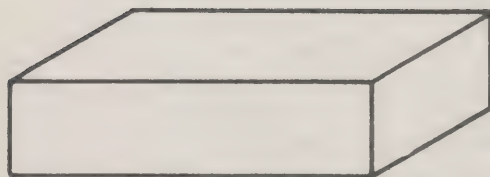


Fig. 125.

Draw the front view 2" long by $\frac{1}{2}$ " high as in fig. 124.

Next draw the slant lines to A, B, and C from 1, 2, and 3 as in fig. 125. These lines are all drawn at the same angles from the horizontal. We have chosen the angle of 30°, but 45° or any convenient angle may be used in a free-hand sketch.



PICTURE DRAWING OF THE BLOCK

Fig. 126.

If the lines A, B, and C are drawn 1" long, or the same length as the actual width of the object, and drawing may be called an oblique drawing. If they are reduced in the drawing to one-half of their true length on the object, the sketch may be called a cabinet type of oblique drawing. Cabinet drawings appear to be more in proportion to the object than do oblique drawings.

Finally, draw lines A-B and B-C to complete the picture drawing as shown in fig. 126.

In the picture drawings already shown, the different surfaces could be located and placed without much difficulty. Sometimes, however, we have to make picture drawings of objects with irregular surfaces that are curved or beveled or cut at angles with the other sides. To help us locate the different points and lines and surfaces on such irregular objects, we use what we might call a "crate" or a "box." This "crate" is rectangular in shape, and uses for size the overall length, width, and height dimensions found in the views. If we then imagine the object as being placed in this "crate," it is easier to draw the object by determining from the views where the object touches the "crate."

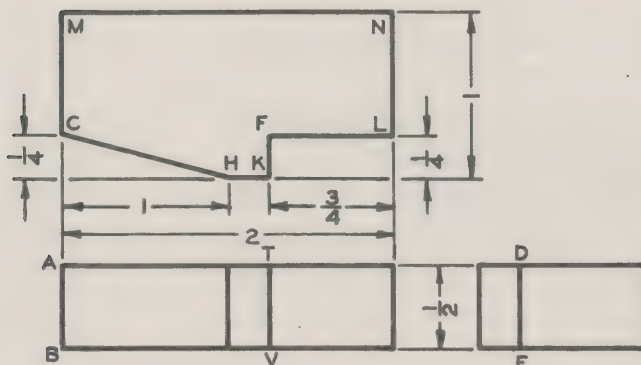


Fig. 127.

Let us see how this principle of shop sketching can be applied to a particular object. As an example, consider the part shown in the Three View Drawing of fig. 127.

To make a picture drawing of the object shown in the Three View Drawing, fig. 127, start with a lightly drawn crate like the one in fig. 126. Find the points C, H, K, F, and L in fig. 127. Locate these points on the crate as in fig. 128 by finding the distance each point is from some corner of

the top of the crate. For example, to locate point K, measure to left the $3/4$ " from the right-hand, near corner of the top of the crate. To locate point F, start at point K and measure $1/4$ " in the same direction as, or parallel to, the right side of the crate.

After these points are located, darken the outline of the top of the object by making the lines heavier.

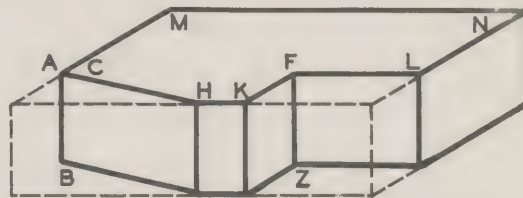


Fig. 128.

Since line A-B is one-half inch long and is directly under point C on the object, we can draw line A-B $1/2$ " down from point C in the picture.

Similarly the line which is under point F in the top view is behind TV in the front view and behind DE in the right-side view. The $1/2$ " dimension between the top and right-side views gives its length.

It can be seen by studying the front and right-side views that a line $1/2$ " long should be drawn straight down from each labeled point of the top view except M. A line is not drawn down from M because the edge it would represent in the picture is hidden by the block.

Connect the bottom ends of the lines necessary to complete the sketch. Study the views and be able to explain in detail how to locate point H and line F-L in the picture drawing.



To draw curved surfaces, we can follow the principle of drawing a crate or frame and using the points where the curve should touch the frame, as an aid in sketching the curve. See fig. 129.

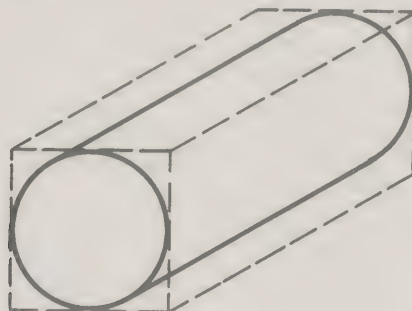


Fig. 129.

A circle shown in the top or side surfaces of oblique drawings will appear as an oval or ellipse.

Here is a method for sketching the approximate shape of these ovals. You can tell from fig. 130 that if you were to sketch a circle in a square, you could use the square as the frame for the circle. First mark the four centers of the sides of the square. Then beginning at each of these points, draw lines which start in the direction of the side and gradually curve away from it.

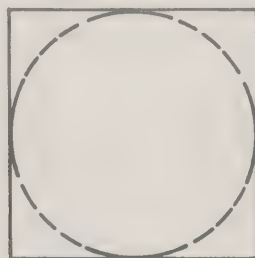


Fig. 130.

To represent circles in the top and right-side views of fig. 131, you follow the same procedure. Complete each circle by blending the unfinished portions. The result is a flattened circle oval.

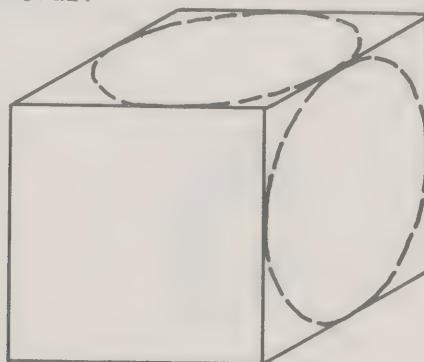


Fig. 131.

OTHER TYPES OF PICTURE DRAWINGS

You now are familiar with oblique drawings commonly used for shop sketches. Another useful type is the **isometric** drawing shown in fig. 132. Once again, it is a picture of the same block shown in fig. 126. One advantage of an isometric drawing is that it does not appear as distorted as the oblique drawing does, although the length, width, and depth lines of the object are drawn to correct scale.

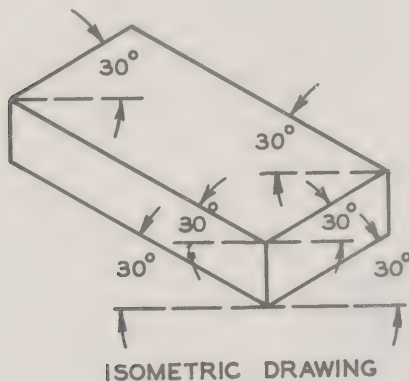


Fig. 132.

Another type of pictorial sketch is the **perspective** drawing. The principle back of the perspective drawing is best understood by thinking about the appearance of a railroad track. If you look down the tracks, as in fig. 133, the rails appear to come together at a point far back in the picture. You know, of course, that the rails are actually the same distance apart at that point as they are where you stand.



Fig. 133.

In other words, the measurement between the two rails looks smaller and smaller as we judge it from greater distances. This principle is called **perspective**.



Fig. 134

In fig. 134, you can see how a house looks when it is drawn in perspective. Since a house is essentially a block, you may be interested in seeing how a block is drawn in perspective. Fig. 135 is a perspective drawing of a block showing how right and left vanishing points are used to determine the direction of the edges of the block.

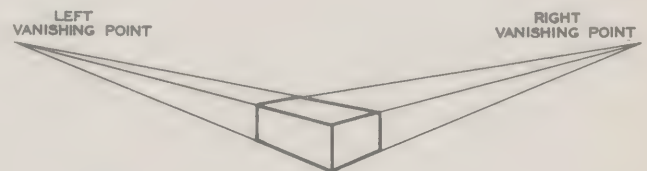


Fig. 135.

Although there are other and more complicated principles which apply to the making of true perspective drawings, the principles in the section are basic. If you practice sketching objects which you see and objects represented in mechanical or Three View Drawings, you will soon be able to make satisfactory picture drawings.

The following illustrations show some of the types of sketches actually used in airplane construction and maintenance work.

In the **figs. 136 and 137** we see two isometric sketches showing some particular detail of small parts of a plane. This type of sketch is necessary in explaining the relationship of one small part to another.

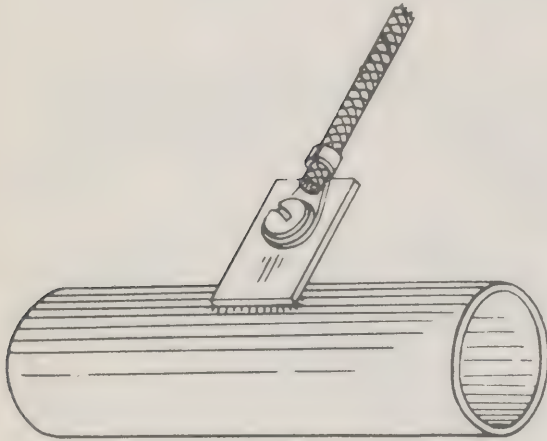


Fig. 136.

Fig. 137.

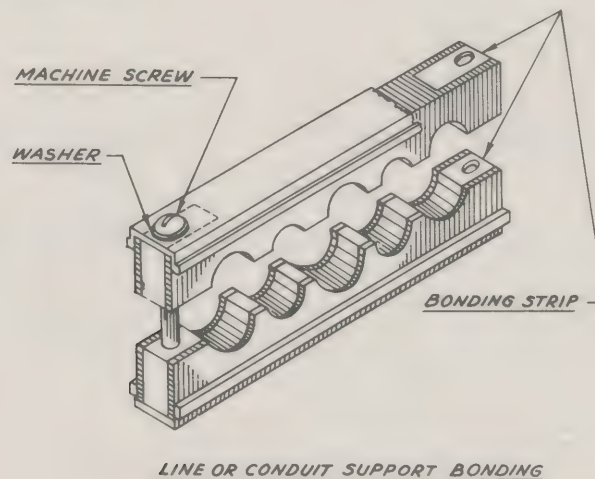


Fig. 138.



FIG. 2F - APPLYING LEATHER PATCH

Many types of small jobs are usually more easily explained with the help of sketches. Fig. 138 is a cabinet drawing showing the method of applying a certain kind of leather patch.

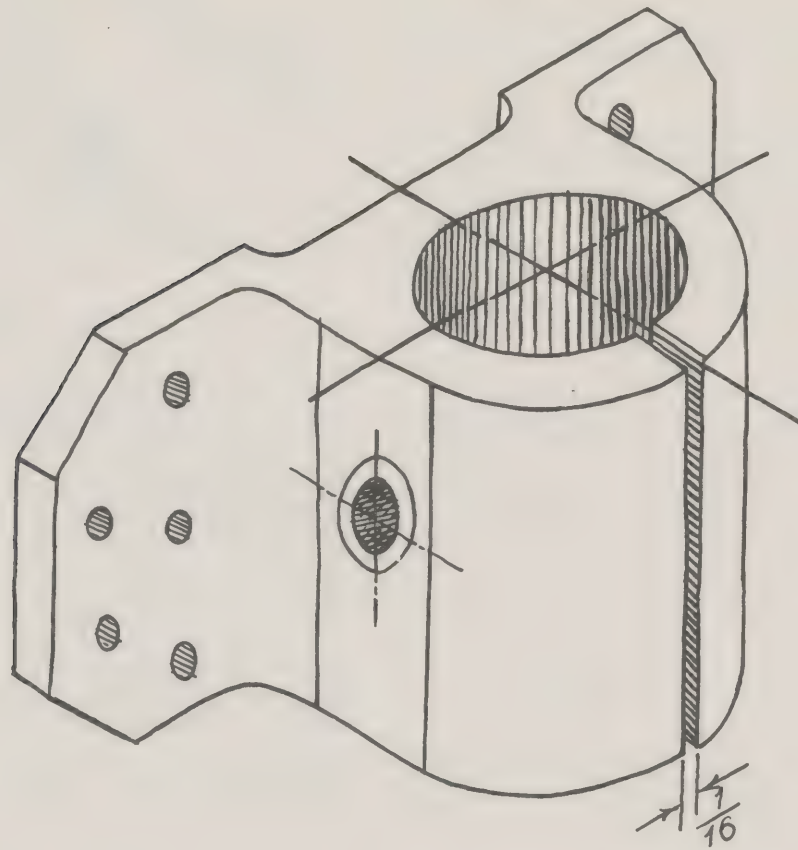


Fig. 139.

Fig. 139 shows a freehand isometric sketch of a support bracket used on an airplane. This type of sketch shows where a particular saw-cut is to be made and how wide the cut should be. Sketches of this type do not take long to make. These drawings convey a clear picture of the part and of the work to be done. You will notice on this sketch that a few fine lines have been added to several of the surfaces. This shading effect has a tendency to separate one surface from another, thereby clarifying the picture in general. Rounded surfaces become generally more natural in appearance if a little shading is added when the drawing is made.

Simple objects can often be sketched in perspective or isometric and then dimensioned, resulting in a perfectly clear explanation of the size and shape of the part.

The sketches in fig. 140 are isometric drawings of standard bucking bars used in connection with rivet guns in shaping rivets. Although each sketch is in very simple outline, the information given is ample for their manufacture.

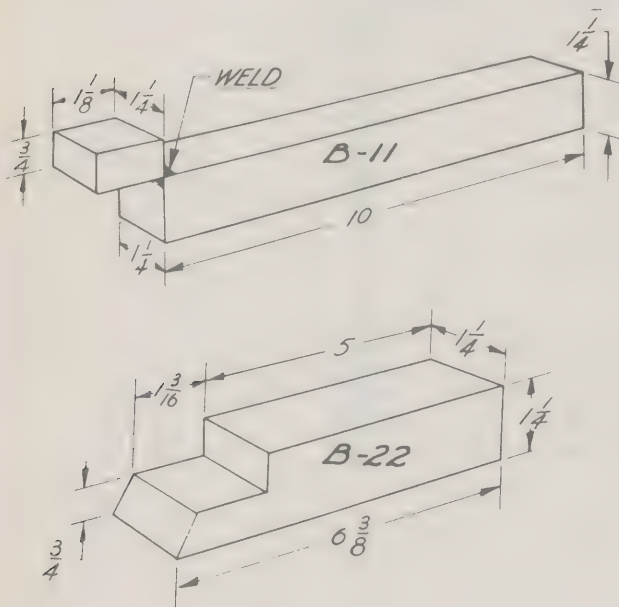


Fig. 140.

You will notice that the dimension lines usually follow the perspective or angle of the lines that they refer to. This method of sketch dimensioning helps to keep the whole picture in the proper feeling of perspective.

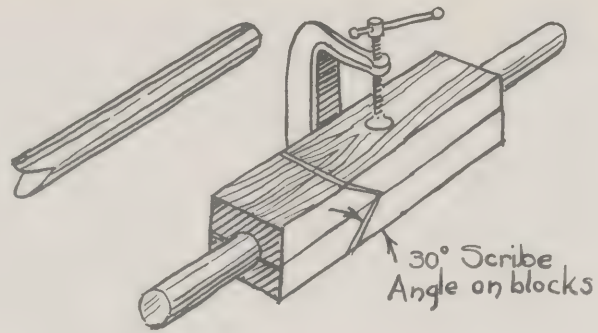
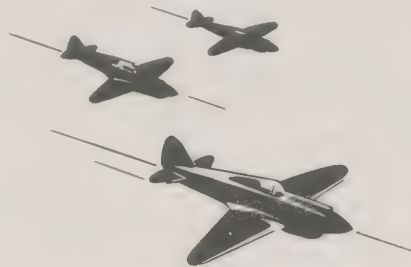


Fig. 141.

Fig. 141 is a sketch of a jig or guide for a cutting tool, showing the jig with one clamp removed. This particular sketch follows the lines of an isometric drawing. In making a sketch of this kind it is not necessary to draw accurately the threads in the clamp. To suggest them is sufficient. Drawing light lines to represent wood grain helps somewhat to explain the drawing. It is noticeable at a glance that the clamp is holding together two pieces of wood. A little shading on the tube helps to show its roundness and gives the impression of the shining surface of metal.

Some types of perspective drawings have been developed to a high degree, and in themselves are very complicated. Fig. 142 is a perspective drawing done by a professional artist of a part of a propeller assembly. Although the drawing itself is very intricate, it clearly shows the general construction and assembly of the various parts. The mechanical drawing of this same part would be very difficult to visualize and would require a drawing such as fig. 142 to help picture assembled unit.



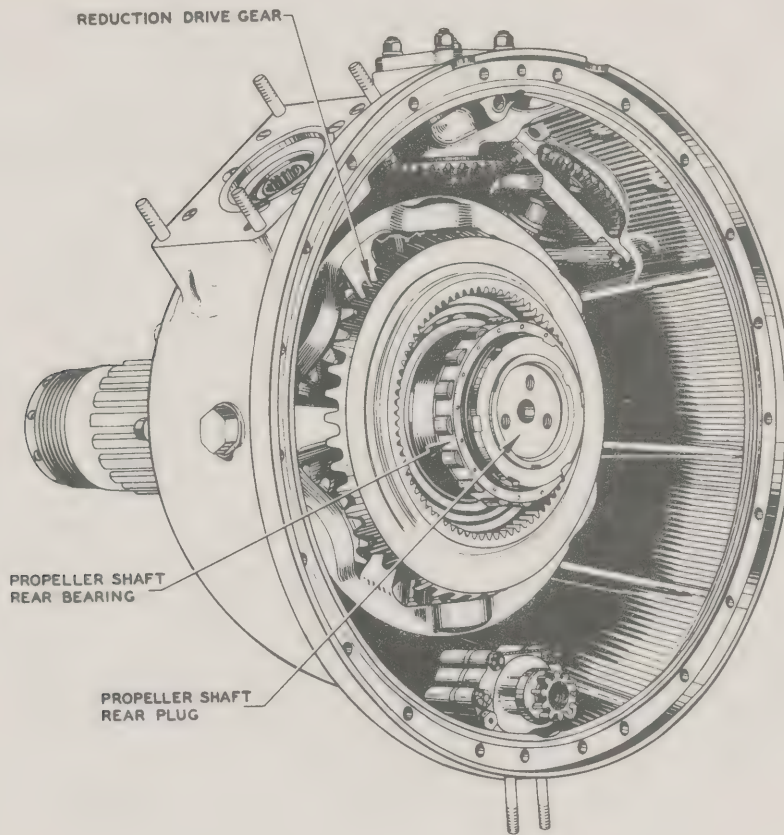


Fig. 142.

Questions

1. What is the difference between the ordinary oblique drawing and a cabinet drawing?
2. Describe the use of a "crate" in making picture drawings.
3. Explain an advantage of isometric drawings.
4. What is the reason for using vanishing points in a perspective drawing?
5. Make an oblique drawing of a block 2" x 2" x 2" and sketch a circle in each of the three surfaces.
6. Referring to figs. 127 and 128, answer the following questions:
 - a. Describe how to locate point H in the picture drawing.
 - b. Explain how you know what measurements to use.
 - c. Describe how to locate point F in the picture drawing.
 - d. Explain how you know what measurements to use.
 - e. Explain how you know where to draw line F-L in the picture.
 - f. Explain how you know where to draw line F-Z in the picture.

